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SOME RESULTS OF A SIMULATION OF AN URBAN SCHOOL DISTRICT.

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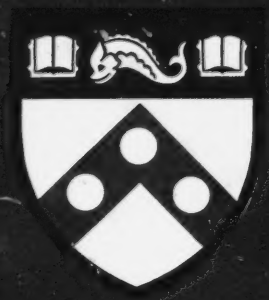
A COMPUTER PROGRAM WHICH SIMULATES THE GROSS OPERATIONAL FEATURES OF A LARGE URBAN SCHOOL DISTRICT IS DESIGNED TO PREDICT SCHOOL DISTRICT POLICY VARIABLES ON A YEAR-TO-YEAR BASIS. THE MODEL EXPLORES THE CONSEQUENCES OF VARYING SUCH DISTRICT PARAMETERS AS STUDENT POPULATION, STAFF, COMPUTER EQUIPMENT, NUMBERS AND SIZES OF SCHOOL BUILDINGS, SALARY, OVERHEAD COSTS, AND INFLATION EFFECTS. PAST AND PRESENT VALUES OF THESE PARAMETERS ARE USED TO CALCULATE FUTURE TRENDS. ADMINISTRATIVE DATA WHICH LIMIT THE MODEL ARE STUDENTS PER STAFF MEMBER, SPACE PER STUDENT, AND COMPUTER EQUIPMENT PER STUDENT. COMMUNITY-ESTABLISHED LIMITS ARE THE OPERATING BUDGET, CAPITAL BUDGET, AND COMPUTER BUDGET. THE SIMULATOR PROGRAM CAN BE USED TO DETERMINE THE OPTIMUM POLICY TO BE ADOPTED IN TERMS OF THE FOREGOING PARAMETERS AND LIMITS. THE FORTRAN PROGRAM IS INCLUDED IN THE APPENDIX. (HM)

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SOME RESULTS OF A SIMULATION
OF AN URBAN SCHOOL DISTRICT

by

Roger L. Sisson



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SOME RESULTS OF A SIMULATION
OF AN URBAN SCHOOL DISTRICT

by

Roger L. Sisson

University of Pennsylvania

March 30, 1967

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Report Number: 042467

This paper describes a simulation model of an urban school district. The results of operating the simulation under various conditions is presented. The results are forecasts of financial requirements and operating statistics.

It is demonstrated that such simulations are feasible and concluded that they are useful.

Based on this model estimates are made of the cost of operating the particular school district under various sets of policy.

MODEL AND RESULTS

The School District of Philadelphia has been modelled by a computer simulation. The purpose of this simulation is to:

- demonstrate the feasibility of simulating an urban school district.
- provide some preliminary guidelines as to the effect of major policy changes on the District's financial outflow and operating statistics.

Both objectives have been accomplished.

The model represents the District as a single aggregated enterprise. The characteristics of the model are these:

- time proceeds on a year-by-year basis; the model provides a "snapshot" of the situation at the end of each year.
- two areas are represented, the inner core and the outer, suburban-like perimeter.
- students are considered a homogeneous population except for the area they are in.
- staff is divided into two groups, paraprofessionals and all others (the latter including teachers, supervisors and management).
- space is represented by the square-feet available and is procured in amounts equal to schools; with appropriate lead times and costs.
- all other services (including non-professionals) and materials

are calculated as "overhead" items on a per student or per square-foot basis.

- all cost factors have appropriate inflation factors associated with them (ranging from 2.5 % to 4 % per year).

The model computes each year's results (starting from the situation at the end of the previous year) according to the procedure outlined in Figure 1.

This model includes several policy variables; factors which can be set by management. The purpose of a model is to explore the consequences of changing these policies. The key policy represented in this model are:

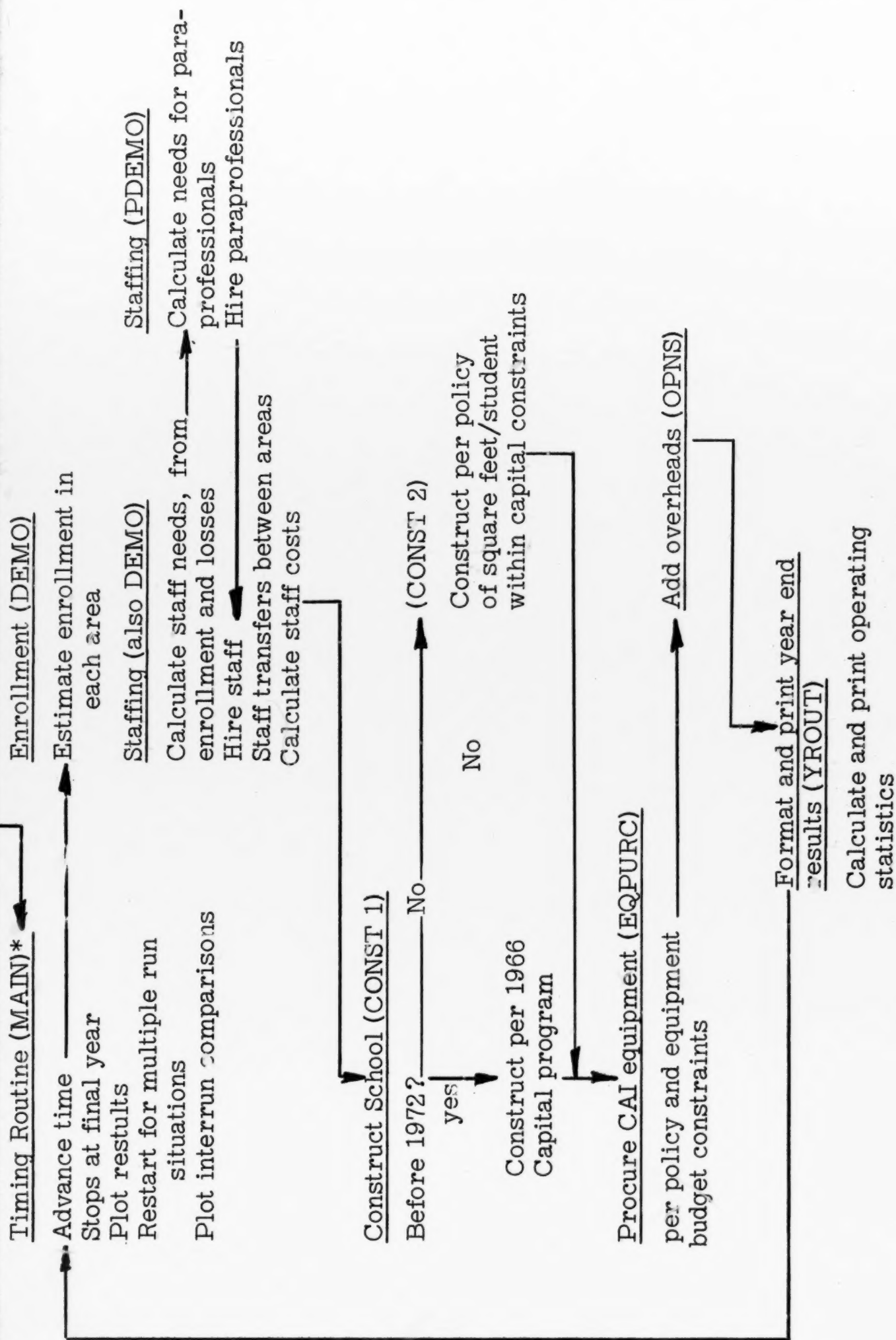
- students per staff (excluding paraprofessionals)
- space per student
- computer-assisted-instruction (CAI) equipment per student
- students per paraprofessional
- paraprofessional per staff
- staff salaries
- paraprofessional staff salaries

These are represented as averages over each of the two areas.

The model also includes three policies set by the community:

- operating budget limit (equivalent to dollars per student).
- capital budget limit.
- computer (CAI) equipment budget limit.

The studies made to date using the model vary these policies in order to determine the effect on the operation in the District. Not all



3. a

OVERALL FLOW CHART

Figure 1

* Subroutine names in capitals

of the policies have been varied in the many possible, or even most of the interesting, combinations. In all studies so far no limit has been set on operating budget and no operating budget allocation procedure is included. The policies actually varied are implied in the description of results below.

Figure 2 shows a typical result at the end of a year. A summary of the operating costs is given, followed by operating statistics and then the capital costs. Other data is available in the computer which is not printed out, such as the proportion of staff assigned to supervising para-professionals.

Figure 3 is a typical summary plot provided by the computer simulation for presentation. Below this data has been transcribed onto special graphs for ease of analysis.

The results can be best understood by reference to Figures 4 through 8.

Figure 4 shows two assumptions used about enrollment. The lower or normal is one of the forecasts now used by the Facilities Planning Department of the District. The upper or pessimistic curve represents a situation which might result if a major shift occurred from private to public schools. Since there are about 500,000 school age children in the city, the pessimistic curve assumes most of them will be in the public schools by 1980.

Figure 5 shows the total operating costs over time that result from various combinations of policies. The A curve is a forecast of

OPERATING COSTS FOR YEAR 1970

STAFF SALARIES	287622212.
PROF. STAFF \$	178382032.
PARAPRCF. STAFF \$	109240182.
TOTAL CVERHEAD	91158890.
CVERHEAD DETAIL	
PLANT OPNS AND MAINT.	31120684.
EQUIPMENT	17782224.
BCKS AND ED. MTL.	7560098.
TRANSPORTATION	5545346.
HEALTH SERVICE	4625354.
REP. AND MAINT. OF EC.	729304.
DEBT SERVICE	27051345.
CCONTRACT SERVICE	12748539.
TOTAL CCSTS	378781100.

OPERATING STATISTICS

293000. STUDENTS IN 12555499. SQ. FT.
FOR AN AVERAGE CF 43. SQ. FT. PER STUDENT

NC. STUDENTS AREA 1	121000.	AREA 2	172000.	TOTAL	293000.
STAFF AREA 1	6514.	AREA 2	9206.	TOTAL	16120.
PCSTITIONS OPEN	1643.				
STUD./STAFF AREA 1	17.5	AREA 2	18.7	TOTAL	18.2

TOTAL PARA. STAFF	19412.	PARA/STU	15.1
PARA. BY AREA	8203.6	11208.1	PARA/STU BY AREA
CAPITAL EXPENDITURES FOR 1970			
ADDITIONS, IMPROVEMENTS, REPAIRS	27768248.		
NEW CONSTRUCTION	52591879.		
TOTAL CAPITAL OUTLAY	80360125.		
CAPITAL EQUIPMENT	0.		

YEAR 70 COMPLETED

Figure 2.

Typical Printout: This is the printout for 1970 in the run that includes hiring and use of paraprofessionals. No CAI equipments is procured in this run.

PARA means paraprofessional
STU means student

GRAPH FOR ABOVE DATA

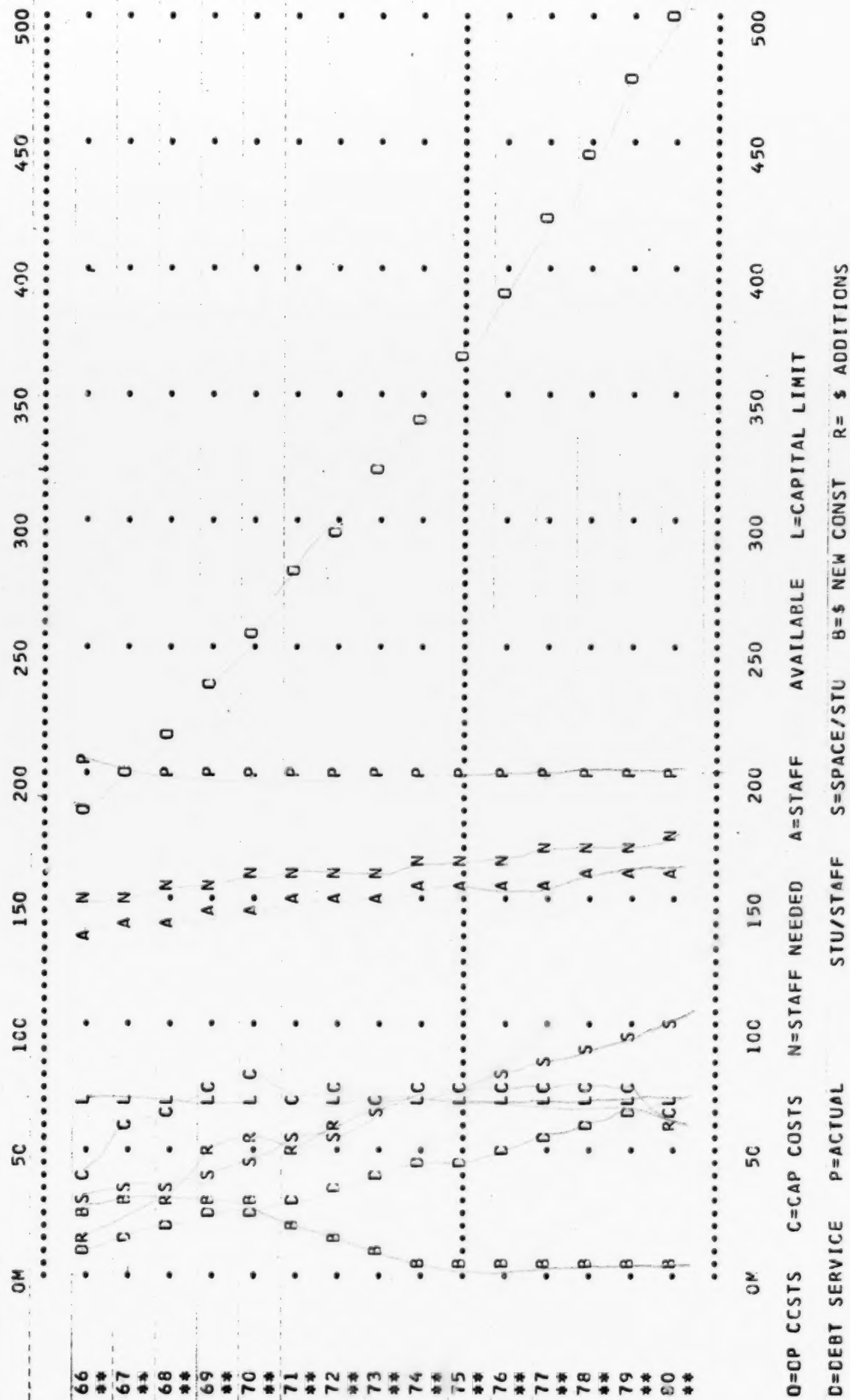


Figure 3.

A plot of data from the run that forecasts costs and operating statistics if no substantial change in policies is undertaken. (Symbols at right show superimposed values.)



Season 3 6 67

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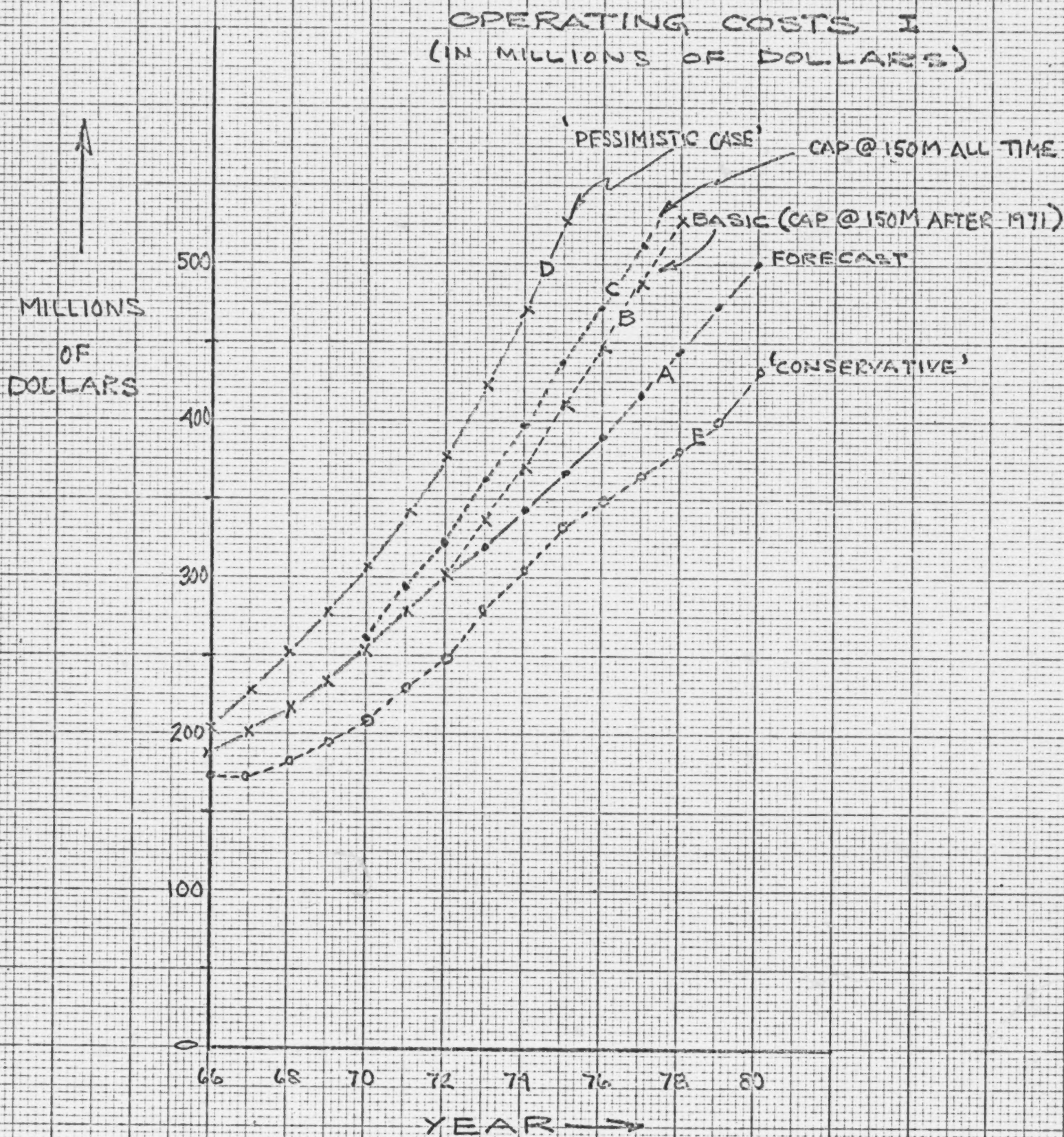


FIGURE 5

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costs if no substantial policy changes are made. In this situation the student/staff policy is 18.5, which is the ratio actually attained in 1965. The space policy is 150 sq.ft. per student. No paraprofessionals nor CAI computer equipment is procured. The capital budget is limited to approximately \$70 million per year and the normal enrollment curve is used.

This A forecast is slightly lower than a five-year forecast recently made by the Finance Division of the School District. The difference is a result of two factors: The model assumes a higher student/staff ratio and also takes into account the fact that not all staff requires can be hired.

The B forecast is the same as A except that the capital budget limit is \$150 million after 1971. The increased costs after 1971 reflect the effect of the added space on the operating costs especially debt service. The C curve is the operating costs for a situation in which the capital budget is \$150 million throughout the period (although this does not have much effect until 1970 due to construction lead times). Curve D is the predicted operating costs under a combination of pessimistic events and generous policies. It represents a "worst case." Here, the enrollment increases according to the pessimistic curve in Figure 4. The desired student/staff ratio is 15 and the space per student is 175 sq. ft. (Lower student/staff ratio implies more teachers and therefore, higher costs.)

Curve E is correspondingly conservative; enrollment is assumed to be lower than the normal curve and a student/staff ratio of 25 and a space-student ratio of 125 are considered satisfactory. This curve re-

presents the lowest costs the District could expect to incur.

Figure 6 demonstrates operating costs under other more dramatic conditions. Curve B is the same as the basic curve - B - in Figure 5; it is included here for reference.

Curve A in Figure 6 represents the School District under a policy which procures CAI systems and utilizes fewer teachers. The budget for equipment is \$30 million per year. Under this limit, computer equipment is acquired until 1973 when there is enough for the entire system. Curve F at the bottom of Figure 6 shows the percentage of students using CAI at each point in time. The student/staff ratio policy for parts of the system with CAI is 35. (However, since staff is not released, but is reduced through attrition this ratio is not attained until 1980.) Note that use of CAI appears to reduce operating costs. Its effect on the education of the students has yet to be determined. Several other studies have been made with equipment budget limits of \$10 million and student/staff ratio of 25. No unexpected forecasts resulted.

Curve C demonstrates an effort to test the effect of an assumption on the results. The model for the runs discussed above assumes that only a fraction (58 %) of the staff needed in any year is actually hired. This represents the supply-demand effects in the market for teachers, i.e., it represents the fact that there are not enough teachers available, and the fact the recruiting facilities are limited. Curve C is the same as curve B except that it assumed that all staff needed can be hired up to a limit of 2000 per year. More staff is hired under this assumption, hence

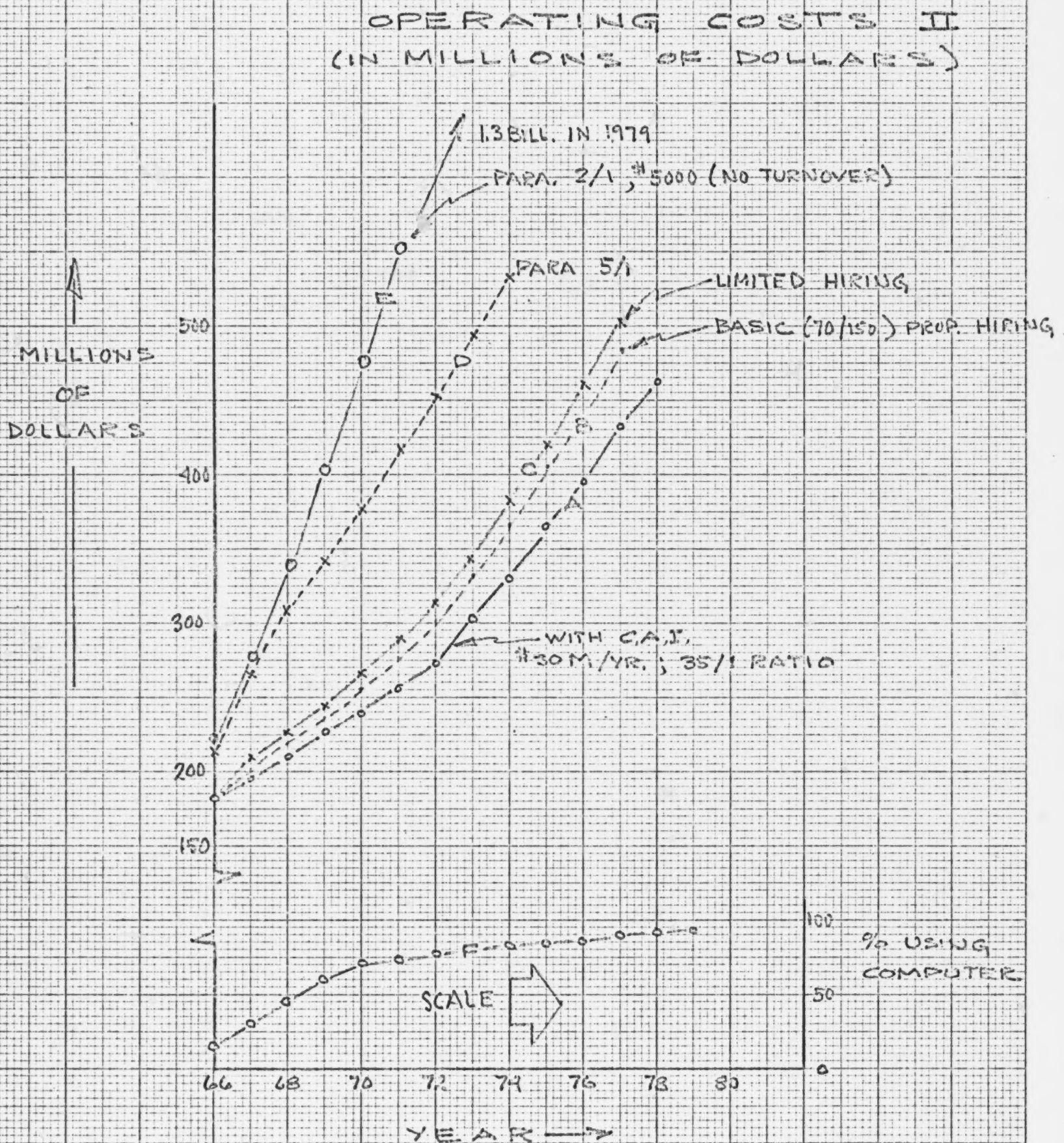


FIGURE 6

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costs are higher. Further study is under way to choose the most valid assumption about staff hiring.

Curve D represents the District operating under a policy in which paraprofessionals (non-certified assistants) are hired to increase the intensity of the educational effort. The goal is to hire enough assistants to obtain a student/paraprofessional ratio of 5. However, limitations on hiring and the turnover of paraprofessional personnel prevent this ratio from going lower than 13.5. The average salary of a paraprofessional is assumed to be \$5000 in 1966 and inflates at 3 % per year. Under this condition the total staff-student ratio in 1975 is estimated to be 7.6. Note that this policy is quite expensive.

Figure 7 shows the staff situation for the basic situation; curve B in figure 5. Note the predicted continued staff shortage.

Figure 8 illustrates the effect of varying capital budgets. The upper curves show the square feet per student realized under three different rates of expenditure. Increasing the budget limit in 1971 to \$150 million does help attain the desired space ratio sooner.

This study is continuing in several directions:

- A model of the sources of funds is being developed so that operating cost limits can be set.
- An attempt is being made to model educational effectiveness (in terms of changes in achievement levels on basic tests)
- A submodel will be incorporated to represent management allocation of operating funds between factors (staff, materials, paraprofessionals).

STUDENT / STAFF RATIO AND STAFF SHORTAGE

STU
STAFF
(MULTIPLY
BY 100
FOR STAFF
SHORTAGE)

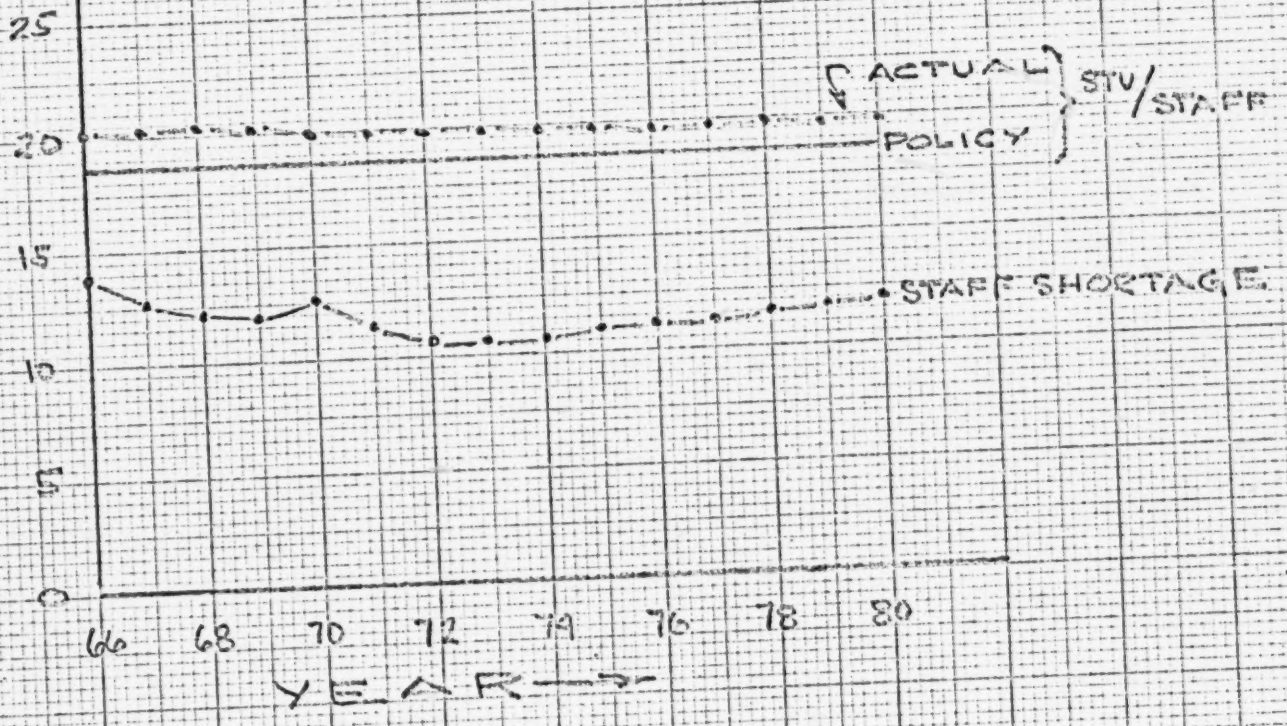


FIGURE 7

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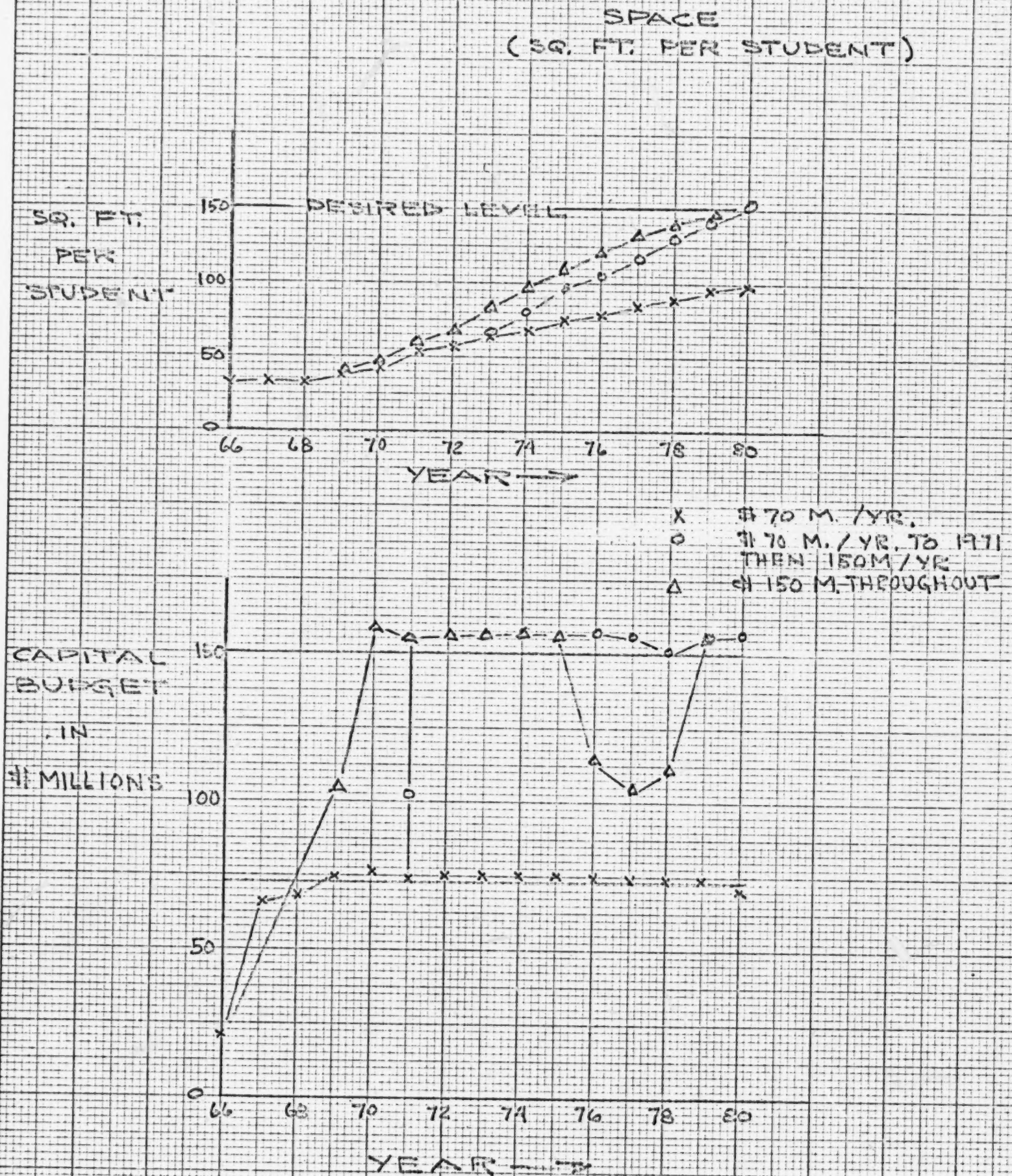


FIGURE 8

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When these additions are completed, a study will be made to determine the settings of the policy factors which give the most effective operation. Another study will try to identify the method of planning which permits the schools to adapt most effectively to changes in the environment (e.g., in student enrollment and student characteristics).

In addition to continuing work on this model, a new, more detailed model is under development. This will contain explicit representations of areas within the district, of student characteristics and achievement and of educational programs.

Planning is under way to perform studies in the School District of Philadelphia to validate this and future models.

TECHNICAL DISCUSSION

The Problem

School districts must allocate limited resources to specific activities (as must any goal-oriented enterprise). There are difficulties in making an optimum allocation in a school district, and especially in a large urban school district. These difficulties ensue partly from some inflexibilities in resources, they stem to a larger extent from non-additive interactions between activities but perhaps, mostly they stem from a lack of well-defined value or objective functions.

The key limited resources of a school district are money, professional manpower and space. In general, availability of materials and non-professional manpower is not a significant limitation. All three of the key limited resources have inflexibilities which restrict their deployment. These inflexibilities are similar to those found in industry but more severe. Manpower is less mobile, even within a city. Many female teachers insist on working near their homes. State laws and sometimes union agreements limit the extent to which teachers can be transferred. Teachers with skills are (at least are perceived to be) non-interchangeable.

Space is also inflexible to some extent. Gyms cannot be used for classrooms (in most designs), but music rooms can be (and often are under today's present crowded conditions) used for other classes.

Completely unlike industrial financing, school districts have a percentage of their funds precommitted. Some funds are available, for example, to be used only for reading, only for preschool, only for the

handicapped or the gifted, only for the construction of classrooms, etc. This precommitment of funds restricts school district management (as was the intention of the administrators of the source of the funds) and complicates the allocation process.

The objective of the education system is to change the present and future behavior (or potential behavior) of the students being educated. The essence of education is the communication process - educating may be thought of as: the communication of information about alternative classes of behavior, the communication of instruction or technical competence in performing certain functions, and in transmitting values for outcomes of various ways of behaving. The activities selected by schools to achieve the objective depend upon the ways in which the schools feel that the informing, instructing, and motivating tasks of education may be efficiently performed.

Only part of the education processes is performed by the schools. A student interacts with many parts of his environment - his mother, father, siblings, peers, communications media, teachers, classmates, and curriculum material. Only the last three are supplied by schools, but the fact that significant education (communication) goes on in the home environment implies that schools must become increasingly involved there through parent groups and community activities.

A basic activity of the school is the creation of an environment in which specially trained adults (or a machine - e.g., film projector or a computer) can communicate specific facts, values, or problems to a

student within a group of students. The creation of such an environment, periodically, will be called an educational program, or simply a program. Because children have a limited attention span and because there is a wide variety of messages to communicate and experience to present, a student participates in several programs, even in one day. The variety of programs is further increased in the urban school district because of the wide range of ages, capability levels of achievement, desires, and environments reflected in the large student population.

This variety causes many administrative problems in the area of organization, personnel selections, curriculum design, and resource allocation. This study focuses on the last of these.

In attempting to solve any of these problems, the educational administrator is trying to obtain the best educational performance possible. There are, however, no agreed-upon measures of educational performance. This lack of a way of evaluating the performance of a teacher, a school, a principal or a district makes the job of administration nearly impossible, inviting petty politics and "suboptimization". The research, of which this study is a part, is attempting to design such measures.

The research is proceeding in phases. The first, reported here involves a model which is limited to the prediction of operating characteristics and financial implications of alternative resource allocations. The next phase will develop measures and techniques for evaluating the educational consequences of resource allocation.

This effort is research; its overall objective is a better understanding of urban school complexes. The models developed may also be valuable to practicing administrators for use in setting priorities, selecting programs and justifying expanded budgets.

Approach

A basic theme of this research is that we must develop precise models of the educational system if we are to make better allocation (and other) decisions. Therefore the principal aims of the study are:

- to design a precise model of an urban educational system expressed as a computer simulation program and
- to explore the consequences of some basic alternative allocations.

The present model is aggregate and therefore exploratory. A more detailed model is under development. Some interesting results have been obtained even with the aggregate representation of the School District; these are reported herein.

Two earlier reports [References 1, 2] have described the overall research and the early development of this model.

Derivation of the Model

The simulation model represents the School District of Philadelphia in sufficient detail to forecast operating and capital costs by major categories.

The first design decision was the selection of a level of aggregation. One could conceive of building a model which represents every teacher - child interaction and every administrative interaction on, say, a minute

by minute basis. This may be the level of detail required in the ultimate model, but is far too complex for the initial effort. (Although in designing the ultimate model we would hope that we have sufficient understanding to abstract many of the detailed processes.) An intermediate model would represent each educational program and its operation over the school year. In an intermediate model, some of the variables that might be represented are:

- geographic areas (schools or clusters of schools),
- detail in classifying teachers (by subject, skill, experience),
- details of educational programs,
- detail in classifying students (by age, achievement, socio-economic factors, IQ),
- recognition of different uses of space,
- various classes of equipments.

Even this level of detail can lead to a very large simulation. (Work on a model at this level is proceeding.) To demonstrate feasibility, a very aggregate model was chosen as a first goal. In this model the following distinctions are made:

- Time proceeds on a year-by-year basis.
- The entire district is divided into two areas (corresponding approximately with areas of disadvantaged and of normal conditions).
- No details of student characteristics are represented (except the area in which they live).

- Staff is distinguished only as to whether it is professional, which includes teachers and administrators, or paraprofessional, which represents non-certified teaching assistants and volunteers. (Non-professional staffing is subsumed in overhead factors.)
- Some detail is given in representation of space. The level of the school (elementary, junior or middle, and senior high) and five different space uses are distinguished.
- Equipment for computer-assisted instruction is separated from all other supporting equipment.
- No categories are recognized within educational materials.
- There is no separate representation of educational programs; changes in programs are assumed to be represented by their effect on aggregate operating characteristics (e.g., staff/student).

The choice of this level of detail was the result of an interactive process which estimated the probable computer program implications of including more detail and, on the other hand, examined the kind of questions one would like to explore with the model when available.

Major Subsystems

A major step in model building is the identification and representation of major subsystems of the phenomena being studied. This is a creative step, for which there are few rules. In any particular case, however, the functional subsystems are usually fairly evident. The discussion below will

make clear the processes included within this model.

A school system's activities are driven by the student enrollment. The first subsystem, therefore, is a demographic process which, in its full form, would represent birth, growth and movements of children in families throughout the district. Separate census and demographic studies have been made in the Philadelphia district. These produced forecasts of enrollment in (approximately) the two areas represented, at five year intervals from 1965 to 1985. The current model starts with these forecasts and does not explicitly represent the demographic process.

A second subsystem includes staffing procedures; hiring, transfers between areas, resignations.

A third subsystem represents the provision of space for teaching. Specifically, it includes the construction of new schools, additions to schools and the demolition of substandard structures.

A fourth subsystem procures computer equipment for computer-assisted instruction (CAI). The schools are just beginning to use such equipment and it is included in order to be able to study the future financial effects of CAI.

Next, one would want to represent the actual process of education. The output of this process would be estimates of the achievement of students as a result of the programs provided. This submodel is under development, but not yet included. Thus the model now represents only the financial and people flows.

A school system provides many supporting services. In the model

these are represented by an overall "overhead" subsystem which estimates costs for these services. Included services are: books and materials procurement, health services, minor equipment procurement, equipment repair and maintenance, miscellaneous consulting and contracted services (e.g., cafeterias), transportation, and debt service on bonds for construction (net of subsidy).

A school district interacts with the remainder of the community in many ways, not represented here. In particular, the generation and input of financial resources through taxes, subsidies and grants is not represented as a process. This system boundary is represented by limits on funding available for capital programs and is ignored for the operating budget. In other words, the system operates as if it could obtain all the operating funds it needs. This unrealistic assumption is being eliminated as the model is refined.

Description of Principal Calculations

Figure 1 is a summary flow chart for this model. In this section the basic algorithms for each process will be presented. Details are given in Appendix 1.

Enrollment

Enrollment forecasts are available for enrollment in the Philadelphia Schools at 5 year intervals from 1965 through 1985. Enrollment is estimated between these points by linear interpolation and by a linear extrapolation of the 1980-1985 forecasts for years beyond 1985. Enrollment is separately estimated for each of the two geographic areas.

Hiring

Next the hiring process is represented. A complete representation would include a submodel of the market - the supply, demand and resulting salary levels - for teachers. The teacher supply process is complex and the development of this submodel would lead away from the main interest of this study (although it has to be done eventually). But we do have to represent the market from the viewpoint of the school district, to account for the fact that it cannot hire all the teacher it needs. This has been represented, approximately, by equations which produce hiring results of the form shown in Figure 9.

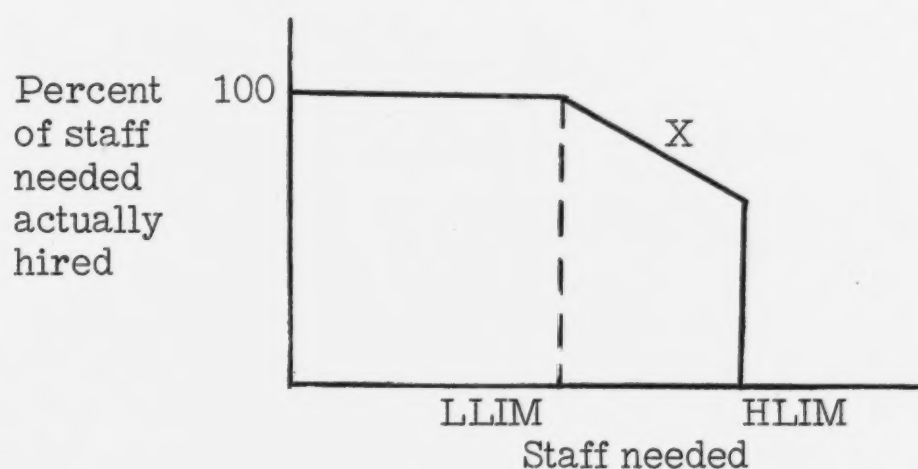


Figure 9.

For needs less than LLIM all needed are hired. In the range from LLIM (often set = 0 in actual runs) to HLIM a proportion, X , of those sought are actually recruited. In any one, year, however no more that same maximum number of appointments, HLIM, can be made. The latter represents the fact that the recruiting and personnel processing capability of the school administration is limited.

The model takes into account transfers between the two areas of staff. Transfer rate between two areas is based on the experience in the 1963 through 1966 period. This however, represents a very small fraction of the total staff required.

Staff costs are calculated by multiplying the available staff by the average salary (including fringe benefits). A cost can be assigned for each person hired (although in the current model this charge was set at 0 and in any case it would be a small fraction of the total operating budget).

An analogous set of relationships is provided for staffing for para-professionals; non-certified assistants and "volunteers."

Space

Space is provided by the construction of schools. (Rentals are not considered in the present model.) This construction is represented by two separate processes; the first applies from 1966 through 1971 and the second thereafter. The first constructs schools according the existing (1966) six year capital budget and plan. After 1971, space is added in relation to a space-per-student goal constrained by a capital expenditure limit.

The first construction routine explicitly represents the level of school and type of space.

In the post -71 routine; schools are added each year in the sequence: Elementary, Middle, High. Each school adds a number of square feet (by categories of use) and incurs costs which are scheduled over 3 to 5 years. Schools are added until either (a) there is enough space (per policy) in all

of the years being scheduled (five) or (b) a capital limit for a year is exceeded. The space needed is derived by multiplying the space-per-student goal by the estimated number of students for the year under consideration.

CAI Equipment

CAI equipment is added in a manner analogous to space construction, but without considering lead time or various types of equipment. The equipment needed in a year is estimated by multiplying the computer cost per student by the number of students and subtracting the equipment already available. The equipment purchased, however, cannot exceed a specified limit.

In addition the desired staff/student ratio is adjusted as computing equipment is procured. For example, without computer a ratio of 15/1 might be desired (recall this is total staff not just teachers). For that portion of the student body that has CAI available the ratio might be 25/1.

Overheads

The various overhead factors are calculated as a function of the most appropriate operating variable. The overhead cost ratios are derived from data available for the 1963 through 1966 period.

The specific overheads are as follows:

- Health Services which are a function of the number of students enrolled.
- Transportation Services also a function of the total enrollment.

- Contract Services which include maintenance and minor repairs to buildings as well as other miscellaneous services; this cost is a linear function of both the total enrollment and the number of square feet of space in the system.
- Books and educational materials which are a function of total enrollment.
- Equipment costs (this is equipment other than that required by CAI) which is a function of total enrollment.
- Repair and maintenance of equipment which is a function of total dollars worth of equipment owned by the system.
- Plant operations and maintenance which is related to the total square feet of space in the system.

Debt service is related to the accumulated construction costs for new buildings over the past years; appropriately decreasing as the debt is paid.

Appendix 1 relates these various calculations to specific part of the computer program.

In addition to these basic computations there are input/output routines:

- to format a report of operating and capital budgets and operating statistics,
- to plot key variable after each run and a few key variables in a comparison of several runs.

Experimental Plan

There are 11 key controllable or policy variables:

- students per staff,
- space per student,
- computer-assisted-instruction (CAI) equipment (\$) per student,
- students per paraprofessional,
- paraprofessional per staff,
- staff salaries,
- paraprofessional staff salaries,
- materials (\$) per student,
- operating budget limit (or dollars per student)
- capital budget limit,
- computer (CAI) equipment budget limit.

The first eight of these are controllable by school administration. The last three are controllable by the community. The studies to date have not varied (or experimented with) all of these. There are also several variables representing the District's environment which we wished to manipulate in order to determine their effect on the budget. Among these are the following:

- population enrollment growth; which we vary to determine the effect of mis-estimating enrollment forecasts.
- the effect of the assumption that the number of staff hired is proportional to, and less than, the staff needed.

There are, of course, many other variables whose effect can be explored with the simulation. However, the runs made during the initial test period were limited to some of these variables. The actual experimental plan is presented in Table 1. The first run, which might be called the basic run, was operated under the following conditions.

- student/staff policy = 18.5 (This was the policy or the actual ratio in effect in 1965)
- Student/space policy = 150 sq. ft. per student. (This is a very generous amount of space, considered desirable by some school facility planning authorities, 60 sq. ft. per student properly designed, may be adequate in an urban district, and additional runs will be made on this basis.)
- Student-paraprofessional ratio. In the basic run no paraprofessionals were hired.

CAI policy. In the basic run it was assumed that no computing facilities were used for teaching purposes.

In the basic run the capital expenditures were limited to 70 million dollars per year which is approximately the limit of it now in effect. Since no CAI was utilized, no budget limit was set for it.

It was assumed that the staff actually hired was 58 % of the new staff needed in any one year. This percentage was the actual experience over the years 1960 through 1965.

The enrollment was assumed to be that established by the forecasts derived by a separate study (see Figure 4).

RUN
(Note 4)

Policy or Parameter	1 Fore- cast	2 Basic	3 Pess- imistic	4 Conser- vative	5 Mixed	6 Hi. Capital	7 Limited Hiring	8	9 CAI	10 CAI	11	12 Para prof.
Stu./staff policy		18.5	15.	25.	18.5/15			25	25	35	35	
Space/stu. policy (1)		150	175	125								
Stu./para policy		No Para.										5
\$CAI/stu. policy		No CAI						700	700	700	700	
Capital limits (2)	70	70/150				150						
CAI Budget limit (2)		-						10	30	30	10	
Hiring (3) assumption		Pro- portional					Fixed Limit					
Enrollment growth		Normal	+3% per yr.	-3%								

- (1) square feet/stu.
(2) millions dollars
(3) see text
(4) entries show changes from run 2.

22.a

Experimental Plan
TABLE 1.

Run 2 is the same as run 1 except that the capital limit increases to \$150 million after 1971. This was taken as the basic run from which all others varied in one or more policy factors.

Run 3 was intended to explore the upper limits of deviations from these policies, but still without such major changes as the extensive use of paraprofessionals or of CAI. The conditions for the second run are shown in Table 1. The student/staff policy is reduced to 15 and the space increased to 175 sq. ft. per student. It was also assumed that the enrollment increases three percent per year (note that this is compounded) faster than the existing forecast. This increase in enrollment would mean that the school system would be teaching most of the elementary and secondary students in the school district area by about 1980 (there is at the present time about 40 % who go to private schools).

Run 4 is a conservative run in which the students per staff is increased and the space decreased and the population assumed to grow more slowly than the forecast.

Run 5 is the same as Run 2 except that the student to staff ratio is assumed to be more favorable (15) in the poverty areas of the city.

Run 6 was an attempt to explore consequences of being able to increase capital expenditures immediately. In this run the capital limit is 150 million per year starting in 1966.

In Run 7 the conditions are the same as in Run 1 except that the following rule is made as to the hiring of personnel: as many teachers or staff as are needed are hired up to a limit of approximately 2000. (The

District has been hiring about 1600 new staff per year in recent years.)

Runs 8 through 11 are runs in which it is assumed that the system buys computers by expending a certain capital budget for computing equipment each year. This budget is \$10 million or \$30 million per year. It also assumes that a satisfactory student-to-staff ratio in the portion of the school district in which computers are used is 25-to-1 or 35-to-1. The four different runs are made by permuting these two conditions (student/staff ratio and limit of expenditures for computers).

In the CAI runs it is assumed that the capital required per student in attendance for the equipment is \$700. This includes terminals and the necessary central computing equipment. It is also assumed that the equipment related (educational software) costs per student are \$50 per year.

Run 12 is a run which is like the basic run except that paraprofessionals are hired. The desired ratio of students to paraprofessionals is 5 to 1. These people, being part time workers and not professionals, should have a high turnover ratio. It is therefore assumed that approximately 30 % of the paraprofessionals leave each year. It is assumed that their salary including all fringe benefits is \$5000 per year (full time equivalent). This is an extreme case, usually most paraprofessionals are non-paid volunteers.

In the paraprofessional run, it is assumed that 1 additional staff member is needed for every 10 paraprofessionals to provide the necessary supervision, and that an additional amount of space (the same as that set aside for one student) is required for each paraprofessional.

Inflation

Most of the cost factors included in the model are inflated by year at varying rates related to estimates of actual inflation found in the literature. In particular, staff costs are inflated at 3 % per year and construction costs at 2.5 % per year.

Conclusions

The principal conclusion from this effort is that it is feasible to model an urban school district. The current model is quite aggregate and represents only very gross policy variables. However, it is clear that (with the proper research manpower) a model can be built which will represent the operation in detail, including representations at specific educational programs and their effect on the system.

The principal conclusions as to school operation from this study to date are:

(1) No matter how the system is operating, the operating costs are going to grow quickly toward \$300 million per year by 1970 to 1972. Use of CAI equipment can apparently reduce these costs; however, the educational effects of such a change have yet to be investigated. The reduction from CAI will not limit the need for major increases in operating revenues.

(2) It appears that the present capital limit (about \$70 million per year) will permit sufficient construction so that the space will increase to a desirable goal (150 sq. ft. per student), but quite slowly. A doubling of the capital budget would permit the space available to increase toward

reasonable levels (100 sq. ft. per student) in the comprehensible future, say 1975. (Note that this model does not include the possibility of renting space; this possibility will be included in future models).

References

1. Sisson, R.L., Applying Operational Analysis to Urban School Districts, Working Paper, Management Science Center, University of Pennsylvania, 1-6-67
2. Stankard, M., and Sisson, R.L., Operations Research and Improved Planning for An Urban School District, Report, Management Science Center, University of Pennsylvania, 1-16-67

APPENDIX 1

Listing and Explanation of the
Features of the Computer Program

MAIN

(Numbers are ISN in listing)

1 - 24	Set up core area
25 - 35	Read run data
36 - 41	Call subroutines with T = 0 to read initial data
42 - 47	Write headings
50 - 117	Set up parameters for each of four runs (1); is the last run: yes
105	Set Capital budget limit, BC (I), for years 2 to 5 to same as year 1 and years 7 through 40 to year 6 (years after start of run), (limit for years 1 and 6 are inputs).
120	Set T to just year (STARTM)
122 - 132	Call subroutines to perform simulation
133	T = last years (STOPTM) ?
136	T = T + 1
141 - 151	Plot results of run (2)
153 - 164	Plot inter-run comparison and stop

```

graph TD
    L133[T = last years (STOPTM) ?] -- yes --> L141[Plot results of run (2)]
    L133 -- no --> L136[T = T + 1]
    L136 --> L133
    L141 --> L153[Plot inter-run comparison and stop]
    L153 --> L153
  
```

(1) The number of runs performed in any single computer "job" can be changed, of course.

(2) GRAPH is a service subroutine for plotting.

07 Sisson SDCAI
N SOURCE STATEMENT

FORTRAN SOURCE LIST

03

```

0 $IBFTC MAIN
1   INTEGER T,STOPTM,STARTM,RO
2   1 FORMAT (I6,I3,I2,I2,I1)
3   3 FORMAT (1H1, 'SCHOOL DISTRICT OF PHILADELPHIA')
4   4 FORMAT(1H0,'PLANNING MODEL - VERSION 1')
5   5 FORMAT(1H0,'RUN NUMBER',1X,I3   ,5X,'DATE',3X,3A6)
6   21 FORMAT (1H1,50H
7   22 FORMAT (1H0,50H
10  23 FORMAT (1H0,50H
11  6 FORMAT(1H0,'PARAMETERS READ')
12  7 FORMAT(1H0,'YEAR',1X,I2,' COMPLETED')
13  COMMON/MASTER/T,STARTM,STOPTM,RO,DOLCEQ,EPS,EL,TDOLEQ
14  COMMON/CSTUP/IYF(4),STUF(4,2)
15  COMMON/XDEMO/X1(2)   ,X3(2),X4(2),X5(2),X6(2),X7(2),X8(2),
16  1X9(2),X10(2),X11(2),PINF
17  COMMON /CDEMO/ POP,STU(2),STFA(2),STFN(2),CSTF(2)
18  COMMON /CONC1/ DOLANN,DTOT(5),DOL,FT2NET   ,BC(40),FSR
20  COMMON /COPNS/ TPOM,TEQ,TBKSED,1TA,THLTH,TRMEQ,TDS,TCNSER,TOH
21  1,R1EQ,R2EQ
22  COMMON/COU/CO(99,9),CC(99,9),GSN(99),GSA(99),GBC(99),
23  1GDS(99),GST(99),GSS(99),GCN(99),GCA(99) ,IR
24  COMMON /CGRA/ 1GT
25  COMMON /CEQ/ FS,XE2(2),XC2(2),X2(2),PERC
26  DIMENSION YX(2)
27
28  C
29  C
30  C   READ MASTER CONTROL PARAMETERS
31  C
32  C
33  25 READ(5,1) RDATE,RUNNO,STARTM,STOPTM,RO
34  C
35  C
36  C   READ RUN NAME, DESCRIPTION
37  31 READ(5,310) DATE1,DATE2,DATE3
38  32 310 FORMAT (3A6)
39  C
40  C
41  33 READ(5,21)
42  34 READ(5,22)
43  35 READ(5,23)
44  C
45  C
46  C   READ SUBPROGRAM PARAMETERS
47  C
48  C
49  36 T=0
50  37 CALL DEMO
51  40 CALL CONST1
52  41 CALL OPNS
53  C
54  C
55  C   WRITE REPORT HEADINGS
56  C
57  C
58  42 WRITE(6,3)

```

7 SISSON SDCAI
SOURCE STATEMENT

FORTRAN SOURCE LIST MAIN

C

WRITE(6,4)
WRITE (6,21)
WRITE (6,22)
WRITE (6,23)
WRITE (6,6)

C RUN CONTROL

DO 40 IR=1,6

C SET UP FOR RUNS

GO TO (300,301,302,303,304),IR

300 FS=.7

X2(1)=.054

X2(2)=.054

PINF=0.

FSR=150.

BC(1)=7.E7

BC(6)=15.E7

R1EQ=50.

R2EQ=50.

EPS=700.

EL=10.E6

IEQSR=1

XC2(1)=.04

XC2(2)=.04

GO TO 110

301 EL=30.E6

GO TO 110

302 EL=10.E6

XC2(1)=.0286

XC2(2)=.0286

GO TO 110

303 EL=30.E6

GO TO 110

304 GO TO 205

110 TDS=10.E6

TDOL EQ=12.E6

DO 120 I=2,5

120 BC(I)=BC(1)

DO 130 I=7,40

130 BC(I)=BC(6)

WRITE (6,5) IR,DATE1,DATE2,DATE3

YX(1)=1./X2(1)

YX(2)=1./X2(2)

YY=1./XC2(1)

WRITE (6,140) YX(1),YX(2),PINF,FSR,BC(1),BC(6),R1EQ,R2EQ,EPS,EL
1,YY

140 FORMAT (' STU/STAFF POLICY',2F10.2/' POPULATION INFLATION FACTOR
1',F10.4/' SPACE POLICY',F10.0/' CAP. BUDGETCONSTRAINT - TO 71',
2F10.0,' BEYOND',F10.0/' EQUIP. COST PER STU.',2F7.3,
3' CAPITAL EQUIP. PER STU.',F8.0/' CAPITAL EQUIPMENT LIMIT',
4F10.0/' STU/STAFF ULTIMATE',F10.2)

C START RUN

T=STARTM

8 FORMAT (1H1)

C
C

007 SISSON SDCAI
 SN SOURCE STATEMENT

FORTRAN SOURCE LIST MAIN

C START SIMULATION
 C
 C

22 30 CALL DEMO
 23 CALL CONST1
 24 CALL OPNS
 25 IF (IEQSR.NE.1) GO TO 31
 30 CALL EQPURC
 31 31 CALL YROUT
 32 WRITE (6,7) T
 33 IF(T.EQ.STOPTM) GO TO 60
 36 T=T+1
 37 GO TO 30

C
 C
 C END OF RUN OUTPUT
 C
 C

140 60 CONTINUE
 141 CALL GRAPH (1,0.,500000000.,6HGRAPH,6HFOR AB,6HOVE DA,6HTA, ,
 16H ,6H ,6H ,4H OM)
 142 CALL GRAPH (2,4H 50,4H 100,4H 150,4H 200,4H 250,4H 300,
 14H 350,4H 400,4H 450,4H 500)
 143 DO 100 IGT= STARTM, STOPTM
 144 100 CALL GRAPH (3,CO(IGT,IR),CC(IGT,IR),GSN(IGT),GSA(IGT),GBC(IGT),
 1GDS(IGT),GST(IGT),GSS(IGT),GCN(IGT),GCA(IGT))
 146 CALL GRAPH (4,Y,Y,Y,Y,Y,Y,Y,Y,Y,Y)
 147 WRITE (6,150)
 150 150 FORMAT('00=OP. COSTS',T21,'C=CAP. COSTS',T41,'N=STAFF NEEDED',
 1T61,'A=STAFF AVAILABLE',T81,'L=TOTAL CAP. EQ.'/'OR=R+M OF EQ.',
 2T21,'P=ACTUAL STU/STAFF',T41,'S=SPACE/STU.',T61,'B=JO10 USING COMPU
 3TER',T81,'R=EQ. COST/YR.'/'1H1)
 151 40 CONTINUE
 153 205 CALL GRAPH (1,0.,500000000.,6HGRAPH,6HFOR AB,6HOVE DA,6HTA, ,
 16H ,6H ,6H ,4H OM)
 154 CALL GRAPH (2,4H 50,4H 100,4H 150,4H 200,4H 250,4H 300,
 14H 350,4H 400,4H 450,4H 500)
 155 DO 210 IGT= STARTM, STOPTM
 156 210 CALL GRAPH (3,CO(IGT,1),CC(IGT,1),CO(IGT,2),CC(IGT,2),CO(IGT,3)
 1,CC(IGT,3),CO(IGT,4),CC(IGT,4),3HEND,Y)
 160 CALL GRAPH (4,Y,Y,Y,Y,Y,Y,Y,Y,Y,Y)
 161 WRITE (6,200)
 162 200 FORMAT ('00COMPARISON OF RUNS'/'00,C= RUN 1 N,A,= RUN 2
 1 L,D=-RUN 3 P,S = RUN 4')
 163 50 STOP
 164 END

YROUT

1 - 10	Set up core
11	Skip this subroutine if $T = 0$
14 - 101	Print output (See example in Figure 2)
102 - 106	Compute statistics about paraprofessionals
107 - 116	Print remaining data
117 - 132	Save this year's values of key variables for plotting routine.

15 SISSCN - SDONE -
N SOURCE STATEMENT

FORTRAN SOURCE LIST

0

0 \$IBFTC YROUT

1 SUBROUTINE YROUT

C
C
C
C
C

YEAR END OUTPUT

2 INTEGER T,STARTM,STOPTM,RO

3 COMMON/MASTER/T,STARTM,STOPTM,RO,DOLCEQ,EPS,EL,TDOLEQ

4 COMMON /CONC1/ DOLANN,DTOT(5),DOL,FT2NET ,BC(40),FSR

5 COMMON /CDEMO/ POP,STU(2),STFA(2),STFN(2),CSTF(2)

6 COMMON /COPNS/ TPCM,TEQ,TBKSED,TTA,THLTH,TRMEQ,TDS,TCNSER,TOH

1,R1EQ,R2EQ

7 COMMON/COU/CO(99,9),CC(99,9),GSN(99),GSA(99),GBC(99),

1GDS(99),GST(99),GSS(99),GCN(99),GCA(99) ,IR

0 COMMON/CPDM/ CPS,PSTFA(2),WUCP(2)

1 IF (T.EQ.0) GO TO 20

C
C
C
C
C

WRITE OPERATING COSTS

4 WRITE (6,1) T

5 1 FORMAT (1H1,'OPERATING COSTS FOR YEAR 19',12)

6 CSTFT=CSTF(1)+CSTF(2)

7 C=CSTFT+CPS

0 WRITE (6,2) C

1 2 FORMAT(1HC,'STAFF SALARIES',T50,F10.0)

2 WRITE(6,30) CSTFT

3 30 FORMAT(1HO,'PROF. STAFF \$',T40,F10.0)

4 WRITE(6,31) CPS

5 31 FORMAT (1H , 'PARAPROF. STAFF \$',T40,F10.0//)

6 WRITE (6,3) TOH

7 3 FORMAT(1X,'TOTAL OVERHEAD',T50,F10.0)

0 WRITE (6,4)

1 4 FORMAT (6X,'OVERHEAD DETAIL')

2 WRITE (6,5) TPCM

3 5 FORMAT(6X,'PLANT CPNS AND MAINT.',T40,F10.0)

4 WRITE (6,6) TEQ

5 6 FORMAT(6X,'EQUIPMENT',T40,F10.0)

6 WRITE (6,7) TBKSED

7 7 FORMAT (6X,'BOOKS AND ED. MTL.',T40,F10.0)

0 WRITE (6,8) TTA

1 8 FORMAT (6X,'TRANSPORTATION',T40,F10.0)

2 WRITE (6,9) THLTH

3 9 FORMAT (6X,'HEALTH SERVICE',T40,F10.0)

4 WRITE (6,10) TRMEQ

5 10 FORMAT(6X,'REP. AND MAINT. OF EQ.',T40,F10.0)

6 WRITE (6,11) TDS

7 11 FORMAT(6X,'DEBT SERVICE',T40,F10.0)

0 WRITE (6,12) TCNSER

1 12 FORMAT(6X,'CONTRACT SERVICE',T40,F10.0)

2 CTOT=TOH+C

3 WRITE (6,13) CTOT

4 13 FORMAT(1X,'TOTAL COSTS',T49,F11.0///)

SISSCN - SCONE -
SOURCE STATEMENT

FORTRAN SOURCE LIST YRCUT

03

WRITE OPERATING STATISTICS

```

WRITE (6,131)
131 FORMAT (1H0, 'OPERATING STATISTICS')
STUT=STU(1)+STU(2)
FT2AVE=FT2NET/STUT
WRITE (6,14) STUT,FT2NET,FT2AVE
14 FORMAT(1H0,F11.0,' STUDENTS IN',F11.0,' SQ. FT.'/
1' FOR AN AVERAGE OF',F8.0,' SQ. FT. PER STUDENT')
STFNT=STFN(1)+STFN(2)
STFAT=STFA(1)+STFA(2)
POSO=STFNT-STFAT
TSR1=STU(1)/STFA(1)
TSR2=STU(2)/STFA(2)
TSRT=STUT/STFAT
WRITE (6,15) STU(1),STU(2), STUT
15 FORMAT (1H0,'NO. STUDENTS AREA 1',F8.0,2X,'AREA 2',F8.0,2X,'TOTAL'
1,F8.0)
WRITE (6,16) STFA(1),STFA(2),STFAT,POSO
16 FORMAT (1X,'STAFF AREA 1',F8.0,2X,'AREA 2',F8.0,2X,'TOTAL',
1F8.0,/' POSITIONS OPEN',F8.0)
IF(POSO .LT. 0.0) WRITE(6,21)
21 FORMAT(1H ,22X,'NOTE..NEGATIVE POSITIONS OPEN IMPLIES SURPLUS STAF
1F THIS YEAR')
WRITE (6,17) TSR1,TSR2,TSRT
17 FORMAT ( 'OSTUD./STAFF AREA 1',F8.1,2X,'AREA 2',F8.1,2X,'TOTAL',
1F8.1///)
TPSTF=PSTFA(1)+PSTFA(2)
TPSR = POP/TPSTF
TPSR1= STU(1)/PSTFA(1)
TPSR2= STU(2)/PSTFA(2)
WRITE(6,32) TPSTF,TPSR
32 FORMAT (1H0,'TOTAL PARA. STAFF',T21,F10.0,T41,'PARA/STU',
1T61,F8.1)
WRITE(6,33) PSTFA(1),PSTFA(2),TPSR1, TPSR2
33 FORMAT(1H0,'PARA. BY AREA',T21,2F10.1,T51,'PARA/STU BY AREA',
1T81,2F8.1)

```

WRITE CAPITAL COSTS

```

WRITE(6,18) T,DOL,DTCT(1),DCLANN
18 FORMAT (1H0,'CAPITAL EXPENDITURES FOR 19',I2// ' ADDITIONS,IMPROVE
1MENTS,REPAIRS',T40,F11.0/1X,'NEW CONSTRUCTION',T40,F11.0/1X,'TOTAL
3 CAPITAL OUTLAY',T50,F11.0)
WRITE (6,19) DCLCEQ
19 FORMAT (1H0,'CAPITAL EQUIPMENT',T50,F11.0///)

```

STORE DATA FOR GRAPHS

015 SISSCN - SCONE -
SN SOURCE STATEMENT

FORTRAN SOURCE LIST YROUT

C

```
117 CC(T,IR)=CTOT  
120 CC(T,IR) = DCLANN  
121 GSN(T)=STFNT*10C00.  
122 GSA(T)=STFAT*10C00.  
123 I11 = T - STARTM + 1  
124 GBC(T)=TPSTF*10C00.  
125 GDS(T)=TPSR*10.E6  
126 GST(T)=TSRT*10.E6  
127 GSS(T)=FT2AVE*1.E6  
130 GCN(T)=DCL  
131 GCA(T)=DTOT(1)  
132 20 RETURN  
133 END
```

DEMO

1 - 12 Set up core

13 $T = 0$ no

16 - 55 Read in or set parameters for this subroutine:
(This sets up for first run; subsequent runs
are set up in MAIN and below.)

56 IIT = years since start of run ←

57 $T > \text{STARTM}$ yes
(if $T = \text{STARTM}$
set up for run)

62 - 63 Set initial staff available (STFA (I)).
I = area; 1 or 2.

64 Calculate initial staff needs (STFN(I)).
X2 (I) = desired staff/student ratio.

66 - 75 Estimate enrollment ←
IYF (I) = year of forecast
I is an index; IYF (1) = 65,
IYF (2) = 70, etc.
FR = interpolation slope
STU (J) = enrollment in area (J)
STUF (I, J) = forecast enrollment at year
indexed I, for area J.

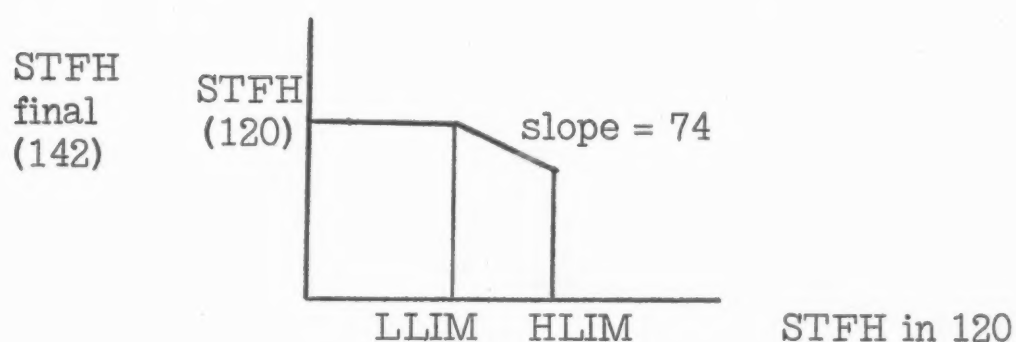
76 - 77 If $T \leq 85$ enrollment is estimated.

101 - 103 Extrapolation to obtain enrollment beyond 1985
(I = 4). RL = extrapolation slope.

105 - 111 Inflate enrollment above forecast if the inflation
factor PINF > 0 .

113 POP = total enrollment

- 114 - 136 Calculate staff hired. I = area index
 STFI, STFO = staff transferring in an out of areas,
 (used at 142 - 164).
 STFL = staff lost, a fraction X3 of staff available at
 end of year
 STFL = staff hired, calculated per this form:



- 142 STFN = New staff needs = enrollment times effective staff/student policy XE2. This effective ratio depends on the extent to which CAI is utilized if paraprofessionals are hired there is another factor, SP which adds needs in relation to staff/parastaff requirements for supervision.
- 143 - 163 Accounts for transfer between areas at a rate X5.
- 164 - 167 Computer staff cost:
 X10 = salary inflation factor
 X6 = average salary
 X11 = fringe benefit cost
 X7 = cost of hiring a staff member
 X8 = cost of resignation
 X9 = cost of a transfer
- 170 - 175 Computes various totals.

015 SISSCN - SDCONE -
 (SN SOURCE STATEMENT

FORTRAN SOURCE LIST

```

0 $IBFTC DEMO
1 SUBROUTINE DEMO
2 INTEGER T, STARTM, STOPTH, RO
3 COMMON/MASTER/T, STARTM, STOPTH, RO, DOLCEQ, EPS, EL, TDOLCEQ
4 COMMON /CDEMO/ POP, STU(2), STFA(2), STFN(2), CSTF(2)
5 COMMON/CSTUP/IYF(4), STUF(4,2)
6 COMMON/XDEMO/X1(2), X2(2), X3(2), X4(2), X5(2), X6(2), X7(2), X8(2),
  1X9(2), X10(2), X11(2), PINF
7 COMMON/CPDM/ CPS, PSTFA(2), WUCP(2)
10 DIMENSION STFI(2), STFO(2), STFH(2), STFL(2), STFAF(2), DIFF(2)
11 DIMENSION STFAX(2), DCFAC(2), SP(2)
12 HLIM=2000.
13 IF(T.GT.0)GO TO 41
16 READ(5,9)((IYF(I),STUF(I,1),STUF(I,2)),I=1,4)
27 9 FORMAT(4(I2,2F6.0))
30 READ(5,1)((X1(I),X2(I),X3(I),X4(I),X5(I),X6(I),X7(I),X8(I),X9(I),
  1X10(I),X11(I)),I=1,2)
41 1 FORMAT(11F6.0)
42 READ(5,2)(STFAX(I),I=1,2)
47 2 FORMAT(2F6.0)
50 DO 14 I=1,2
51 14 STFN(I)=X2(I)*STUF(1,I)
53 DO 15 I=1,2
54 15 SP(I)=.10
56 CALL PCDEMO
57 RETURN
60 41 IIT=T-STARTM
61 IF(T.NE.STARTM) GO TO 3
64 DO 40 I=1,2
65 40 STFA(I)=STFAX(I)
67 DO 100 I=1,2
70 100 STFN(I)=X2(I)*STUF(1,I) +SP(I)*PSTFA(I)
72 3 DO 10 I=2,4
73 IF(T.GT.IYF(I))GO TO 10
76 FR=FLOAT(T-IYF(I-1))/5.
77 DO 11 J=1,2
100 11 STU(J)=FR*STUF(I,J)+(1.0-FR)*STUF(I-1,J)
102 GO TO 12
103 10 CONTINUE
105 DO 13 J=1,2
106 RL=(STUF(4,J)-STUF(3,J))/5.
107 13 STU(J)=STUF(4,J)+FLOAT(T-IYF(4))*RL
111 12 IF (PINF.EQ.0.) GO TO 25
114 DO 20 I=1,2
115 20 STU(I)=STU(I)*((1.+PINF)**IIT)
117 25 POP=STU(1)+STU(2)
120 DO 60 I=1,2
121 STFI(I)=0.0
122 STFO(I)=0.0
123 STFL(I)=X3(I)*STFA(I)
124 60 STFH(I)=X4(I)*(STFN(I)-STFA(I)+STFL(I))
126 TSTFH=STFH(1)+STFH(2)
127 IF (TSTFH.LE.HLIM) GO TO 55
132 DO 50 I=1,2
133 50 STFH(I)= (STFH(I)/TSTFH)*HLIM

```

```

015  SISSCN - SCONE -          FORTRAN SOURCE LIST DEMO
SN      SOURCE STATEMENT

35  55  CALL PDEMO
36      DO 5 I=1,2
37      IF(STFH(I).LT.0.0)STFH(I)=0.0
42      STFNI(I)=X2(I)*STU(I)    +SP(I)*PSTFA(I)      (See Note)
43      STFAF(I)=STFA(I)+STFH(I)-STFL(I)
44  5   DIFF(I)=STFAF(I)-STFNI(I)
46      XT=DIFF(1)*DIFF(2)
47      IF(XT.GE.0.0)GO TO 7
52      IF(DIFF(1).GT.0.0)GO TO 6
55      DIFF(1)=-DIFF(1)
56      STFI(1)=X5(1)*AMIN1(DIFF(1),DIFF(2))
57      STFO(2)=STFI(1)
60      GO TO 7
61  6   DIFF(2)=-DIFF(2)
62      STFI(2)=X5(2)*AMIN1(DIFF(1),DIFF(2))
63      STFO(1)=STFI(2)
64  7   DO 8 I=1,2
65      STFA(I)=STFAF(I)+STFI(I)-STFO(I)
66      ITT=T-STARTM+1
67      DCFAC(I)=((1.+X10(I))*ITT)*(X6(I)+X11(I))
70  8   CSTF(I)=DCFAC(I)*STFA(I)+X7(I)*STFH(I)+X8(I)*STFL(I)+
1X9(I)*(STFI(I)+STFO(I))
72      STFNT=STFNI(1)+STFNI(2)
73      STFAT=STFA(1)+STFA(2)
74      STFHT=STFH(1)+STFH(2)
75      STFLT=STFL(1)+STFL(2)
76      STR=POP/STFAT
77      RETURN
200     END

```

Note: In CAI runs XE2 is used here instead of X2.
XE2 is calculated in subroutine EQPURC.

PDEMO

(This subroutine called from DEMO where paraprofessional staff is to be hired.)

- 1 - 6 Set up core.
- 7 - 22 Set up parameters before first run ($T = 0$).
- 23 - 26 Compute parastaff hired:
 I = area index
 PSTFA = parastaff available
 PSTFL = parastaff resignations (a proportion, PL, of
 parastaff available at end of year)
 PH = staff hired
 PX2 = parastaff/student ratio, policy
- 30 - 35 Limits total hires per year to PLIM
- 37 - 43 Computes cost of paraprofessional staff
 UCP = average salary including fringe benefits
 PPINF = inflation rate of paraprofessional salaries
 WUCP = total cost in area
 CPS = total cost

015	SISSCN - SCONE -	FORTRAN SOURCE LIST
SN	SOURCE STATEMENT	

```

0 $IBFTC PDEMO
1  SUBROUTINE PDEMO
2  INTEGER T,STOPTM,STARTM,RO
3  COMMON/MASTER/T,STARTM,STOPTM,RO,DOLCEQ,EPS,EL,TDOLEQ
4  COMMON /CDEMO/ POP,STU(2),STFA(2),STFN(2),CSTF(2)
5  COMMON/CPDM/ CPS,PSTFA(2),WUCP(2)
6  DIMENSION PL(2), UCP(2), PX2(2) ,PSTFL(2) , PH(2)
7  IF(T.GT.0) GO TO 1
12 DO 3 I=1,2
13  PL(I)=.3
14  PLIM=7000.
15  LCP(I)=5000.
16  PX2(I)=.2
17  3 PSTFA(I)=0.
21  PPINF=.03
22  RETURN
23  1 ITT=T-STARTM
24  DO 2 I=1,2
25  PSTFL(I)=PL(I)*PSTFA(I)
26  2 PH(I)=(PX2(I)*STU(I) )-PSTFA(I)+PSTFL(I)
30  PT=PH(1)+PH(2)
31  IF (PT.LT.PLIM) GO TO 4
34  DO 5 I=1,2
35  5 PH(I)=(PH(I)/PT)*PLIM
37  4 DO 6 I=1,2
40  PSTFA(I)= PSTFA(I)+PH(I) -PSTFL(I)
41  6 WUCP(I)=UCP(I)*((1.+PPINF)**ITT) *PSTFA(I)
43  CPS=WUCP(1)+WUCP(2)
44  RETURN
45  END

```

CONST 1

1 - 21	Set up core
22 - 271	Read in initial parameters and values.
272	Call CONST 2 to allow its initial values to be read.
274 - 320	Re-establish values for next run.
323 - 325	Calculate cost inflation factor CFAC based on annual increase CINF and years after start IIT.
326 - 331	Calculate cost of units: TCNEW = new schools, TCAAD = additions, TCREP = a standard unit of repair; for 5 types of space.
333 - 342	Compute number of units now in system NUMNEW, etc. based on preplanned program (1966, 6-year capital program).
344	If year (since start) MMT is greater than last year of capital program LFLAG, call CONST 2 for continuing the construction process (CONST 2 returns with new NUMNEW).
347 - 440	Compute cost DOLNEW, etc., of construct for the year. DOLANN is the overall total: DOT (1) = cost of new construction, DOL = Cost of additions and repairs.
441 - 527	Compute total square feet FT2NET = total square feet in the system.
532 - 600	Adjusts data for next year.

015 SISSCN - SDONE -
SN SOURCE STATEMENT

FORTRAN SOURCE LIST

0

```

0 $IRFTC CONST1
1 SUBROUTINE CONST1
2 INTEGER T, STARTM, STOPTM, RO
3 COMMON/MASTER/T, STARTM, STOPTM, RO, DOLCEQ, EPS, EL, TDOLEQ
4 COMMON /CON01/ DOLANN, DTOT(5), DCL, FT2NET , BC(40), FSR
5 COMMON/CON02/ NUMNEW, NUMADD, NUMREP, NDEMO
6 COMMON/CON03/ SP1, SP2, SP3, SPD
7 COMMON/CON04/ TCNEW, TCADD, TCREP
10 COMMON/CON05/ FRDCLN, FRDOLA, FRDCLR
11 10 FORMAT(40I2)
12 11 FORMAT(5F10.0)
13 13 FORMAT(F10.0)
14 14 FORMAT(20F5.0)
15 20 FORMAT(7I5)
16 DIMENSION AA1(5,2), TXNEW(5), TXADD(5), TXREP(5)
17 DIMENSION MAXN(5), MAXA(10), MAXR(5)
20 DIMENSION NUMN(5,40), NUMA(5,40), NUMR(5,40), NDEMO(5,40), FRDCLN(5,5),
1 , FRDOLA(10,5), FRDCLR(5,5), TCNEW(5), TCADD(10), TCREP(5), AFACTR(5),
2 SPINIT(10), SPFRN(5,10), SPFRR(5,10), SPFRD(5,10), SP1(5), SP2(10),
3 SP3(5), SPD(5), NUMNEW(5,5), NUMADD(10,5), NUMREP(5,5), DCLNEW(5,5),
4 DOLADD(10,5), DOLREP(5,5), DSUMN(5), DSUMA(10), DSUMR(5),
5 SPNEW(5), SPADD(10), SPREP(5), ADDSPN(5,10), ADDSPR(5,10), ADDN(10),
6 ADDR(10), ASPACE(10), MDEMOL(5), SPDEM(5), SUBD(10), SPANET(10)
21 DIMENSION SPANX(10), NUMNX(5,5), NUMAX(10,5), NUMRX(5,5)
22 IF(T .NE. 0) GO TO 100
25 NPER = STOPTM - STARTM + 1
26 READ(5,20) NNMAX, NAMAX, NRMAX, MAXSTN, MAXSTA, MAXSTR, LFLAG
36 DO 40 I=1, NNMAX
37 40 READ(5,10) (NUMN(I,J), J=1, NPER)
45 DO 45 I=1, NAMAX
46 45 READ(5,10) (NUMA(I,J), J=1, NPER)
54 DO 50 I=1, NRMAX
55 50 READ(5,10) (NUMR(I,J), J=1, NPER)
63 DO 55 I=1, NNMAX
64 55 READ(5,11) (FRDCLN(I,J), J=1, MAXSTN)
72 DO 60 I=1, NAMAX
73 60 READ(5,11) (FRDOLA(I,J), J=1, MAXSTA)
101 DO 65 I=1, NRMAX
102 65 READ(5,11) (FRDCLR(I,J), J=1, MAXSTR)
110 READ(5,11) (TXNEW(I), I=1, 5)
115 READ(5,11) (TXADD(I), I=1, 5)
122 READ(5,11) (TXREP(I), I=1, 5)
127 READ(5,13) AFACTR(1)
130 READ(5,11) (SPANX (J), J=1, 5)
135 FT2NET = 0.0
136 DO 68 J=1, NAMAX
137 68 FT2NET = FT2NET + SPANET(J)
141 READ(5,10) (MAXN(I), I=1, 5), (MAXA(I), I=1, 10), (MAXR(I), I=1, 5)
156 DO 70 I=1, NRMAX
157 70 READ(5,10) (NDEMO(I,J), J=1, NPER)
165 DO 75 I=1, NNMAX
166 75 READ(5,14) (SPFRN(I,J), J=1, NAMAX)
174 DO 80 I=1, NRMAX
175 80 READ(5,14) (SPFRR(I,J), J=1, NAMAX)
203 DO 85 I=1, NRMAX

```

```

015  SISSCN - SDONE -          FORTRAN SOURCE LIST CONST1
SN      SOURCE STATEMENT

04      85 READ(5,14) (SPFRD(I,J),J=1,NAMAX)
12      READ(5,11) (SP1(I),I=1,5)
17      READ(5,11) (SP2(I),I=1,5)
24      READ(5,11) (SP3(I),I=1,5)
31      READ(5,11) (SPD(I),I=1,5)
C      INITIAL CONDITIONS
36      READ(5,10) ((NUMNX (I,J),J=2,5),I=1,NNMAX)
47      READ(5,10) ((NUMAX (I,J),J=2,5),I=1,NAMAX)
60      READ(5,10) ((NUMRX (I,J),J=2,5),I=1,NRMAX)
71      CINF=.025
72      CALL CONST2
73      GO TO 400
C      T IS GREATER THAN ZERO
74      100 IF(T.NE.STARTM) GO TO 200
77      FT2NET=0.
00      DO 101 J=1,5
01      SPANET(J)=SPANX(J)
02      101 FT2NET=FT2NET+SPANET(J)
04      DO 102 I=1,NNMAX
05      DO 102 J=2,5
06      102 NUMNEW(I,J)=NUMNX(I,J)
11      DO 103 I=1,NAMAX
12      DO 103 J=2,5
13      103 NUMADD(I,J)=NUMAX(I,J)
16      DO 104 I=1,NRMAX
17      DO 104 J=2,5
20      104 NUMREP(I,J)=NUMRX(I,J)
23      200 MMT = T - STARTM+1
C      ADJUST FOR INFLATION
24      IIT=T-STARTM
25      CFAC=(1.+CINF)**IIT
26      DO 105 I=1,5
27      TCNEW(I)=TXNEW(I)*CFAC
30      TCADD(I)=TXADD(I)*CFAC
31      105 TCREP(I)=TXREP(I)*CFAC
33      DO 205 I=1,NNMAX
34      205 NUMNEW(I,1) = NUMN(I,MMT)
36      DO 206 I=1,NAMAX
37      206 NUMADD(I,1) = NUMA(I,MMT)
41      DO 207 I=1,NRMAX
42      207 NUMREP(I,1) = NUMR(I,MMT)
44      IF(MMT .GT. LFLAG) CALL CONST2
47      DO 215 J=1,MAXSTN
50      DO 210 I=1,NNMAX
51      210 COLNEW(I,J) = FLOAT(NUMNEW(I,J))*TCNEW(I)*FRDOLN(I,J)
53      215 CONTINUE
55      DO 220 J=1,MAXSTA
56      DO 216 I=1,NAMAX
57      216 COLADD(I,J) = FLOAT(NUMADD(I,J))*TCADD(I)*FRDOLA(I,J)
61      220 CONTINUE
63      DO 225 J=1,MAXSTR
64      DO 221 I=1,NRMAX
65      221 COLREP(I,J) = FLOAT(NUMREP(I,J))*TCREP(I)*FRDOLR(I,J)
67      225 CONTINUE
71      DO 230 I=1,NNMAX

```

```

015  SISSCN - SDONE -          FORTRAN SOURCE LIST CONST1
ISN   SOURCE STATEMENT

372   CSUMN(I) = 0.
373   CO 226 J=1,MAXSTN
374   226 CSUMN(I) = DSUMN(I) + DOLNEW(I,J)
376   230 CONTINUE
400   CO 235 I=1,NAMAX
401   CSUMA(I) = 0.
402   CO 231 J=1,MAXSTA
403   231 CSUMA(I) = DSUMA(I) + DCLADD(I,J)
405   235 CONTINUE
407   CO 240 I=1,NRMAX
410   CSUMR(I) = 0.
411   CO 236 J=1,MAXSTR
412   236 CSUMR(I) = DSUMR(I) + DCLREP(I,J)
414   240 CONTINUE
416   DTOT(1) = 0.
417   CO 241 I=1,NNMAX
420   241 DTOT(1) = DTOT(1) + DSUMN(I)
422   DTOT(2) = 0.
423   CO 242 I=1,NAMAX
424   242 DTOT(2) = DTOT(2) + DSUMA(I)
426   DTOT(3)=0.
427   CO 243 I=1,NRMAX
430   243 DTOT(3)=DTOT(3)+DSUMR(I)
432   DUMMY=0.
433   CO 245 K=1,3
434   245 DUMMY = DUMMY+DTOT(K)
436   DTOT(4)= AFACTR(1)*DUMMY
437   COL = DTOT(4) + DTOT(2) + DTOT(3)
440   COLANN = DUMMY + DTOT(4)
    C  CALCULATION OF SPACE CHANGES THIS PERIOD
441   CO 270 I=1,NNMAX
442   K=MAXN(I)
443   270 SPNEW(I) = FLOAT(NUMNEW(I,K      ))*SP1(I)
445   CO 275 I=1,NAMAX
446   K=MAXA(I)
447   275 SPADD(I) = FLOAT(NUMADD(I,K      ))*SP2(I)
451   CO 280 I=1,NRMAX
452   K=MAXR(I)
453   280 SPREP(I) = FLOAT(NUMREP(I,K      ))*SP3(I)
455   CO 290 I=1,NNMAX
456   CO 285 J=1,NAMAX
457   285 ADDSPN(I,J) = SPNEW(I)*SPFRN(I,J)
461   290 CONTINUE
463   CO 295 I=1,NRMAX
464   CO 291 J=1,NAMAX
465   291 ACDSPR(I,J) = SPREP(I)*SPFRR(I,J)
467   295 CONTINUE
471   CO 305 J=1,NAMAX
472   ADDN(J)=0.
473   CO 301 I=1,NNMAX
474   301 ADDN(J) = ADDN(J) + ADDSPN(I,J)
476   ADDR(J)=0.
477   CO 303 I=1,NRMAX
500   303 ACDR(J) = ADDR(J) + ACDSPR(I,J)
502   305 CONTINUE

```



```
015 SISSON - SDONE - FORTRAN SOURCE LIST CONST1
SN SOURCE STATEMENT
```

```

04      CO 310 J=1,NAMAX
05      310 ASPACE(J) = ADDN(J) + SPADD(J) + ADDR(J)
07      CO 315 I=1,NRMAX
10      MDEMOL(I) = NDEMO(I,MNT)
11      315 SPDEM(I) = FLOAT(MDEMOL(I))*SPD(I)
13      CO 325 J=1,NAMAX
14      SUBD(J)=0.
15      CO 320 I=1,NRMAX
16      320 SUBD(J) = SPDEM(I)*SPFRD(I,J)+SUBD(J)
20      325 CONTINUE
22      CO 330 J=1,NAMAX
23      330 SPANET(J) = ASPACE(J) - SUBD(J)
25      FT2TOT = 0.0
26      CO 340 J=1,NAMAX
27      340 FT2TOT = FT2TOT + SPANET(J)
31      FT2NET = FT2NET + FT2TOT
    C    SHIFTING TO GO TO NEXT PERIOD
32      CO 365 I=1,NNMAX
33      K=MAXN(I)
34      IF(K .LT. 2) GO TO 365
37      CO 360 J = 1,K
40      M = K - J
41      IF(M .EQ. 0) GO TO 365
44      360 NUMNEW(I,M+1) = NUMNEW(I,M)
46      365 CONTINUE
50      CO 375 I=1,NAMAX
51      K=MAXA(I)
52      IF(K .LT. 2) GO TO 375
55      CO 370 J = 1,K
56      M = K - J
57      IF(M .EQ. 0) GO TO 375
62      370 NUMADD(I,M+1) = NUMADD(I,M)
64      375 CONTINUE
66      CO 385 I=1,NRMAX
67      K=MAXR(I)
70      IF(K .LT. 2) GO TO 385
73      CO 380 J = 1,K
74      M = K - J
75      IF(M .EQ. 0) GO TO 385
80      380 NUMREP(I,M+1) = NUMREP(I,M)
82      385 CONTINUE
84      400 RETURN
85      END

```

CONST 2

- 1 - 20 Set up core
- 21 - 50 Set up initial conditions
- 24 - 36 Computes crude parameters for forecasting enrollment by a linear extrpolation; with constant A1 and slope B1. This is based on the past two years.
- 51 - 53 Compute enrollment APF3 from A1 and B1. Add paraprofessional staff, PSTFA, who also need space. (Staff needs are assumed to be negligible at this level of aggregation.)
- 54 - 73 Calculate space available, YYY, from construction previously authorized, in year being planned. SPI is space per unit.
- 74 - 75 If space available exceeds policy requirements, return.
- 100 - 155 Calculate cost of construction in process for years under planning (next three). DXXX (K) is total cost in year K.
- 157 - 163 Compare cost to budget BC (K). If exceeded, return, otherwise go on to add construction.
- 165 - 176 See if new construction will exceed budget. If so, if not go on (Note that one school over budget can be authorized).
- 203 NY = added school
- 204 - 206 If space exceeded
- 211 - 212 Add schools of each level (elementary, middle, high) and then repeat (at statement 392) until one of the limits is exceeded. Here 4 elementary schools are needed.
- 215 - 222 Check cost
- 224 - 243 Add two middle schools
- 245 - 253 Add one high school
- 255 - 256 Update new school count for years under consideration
- 261 Return to main construction simulation CONST 1.
-
- ```

graph TD
 165-176 --> 204-206
 204-206 --> 261
 204-206 --> Exit(())

```

015 SISSCN - SDONE -  
ISN SOURCE STATEMENT

## FORTRAN SOURCE LIST

```

0 $IBFTC CONST2
1 SUBROUTINE CONST2
2 INTEGER T, STARTM, STOPTH, RO
3 COMMON/MASTER/T, STARTM, STOPTH, RO, DOLCEQ, EPS, EL, TDOLEQ
4 COMMON/CSTUP/IYF(4), STUF(4,2)
5 COMMON /CONC1/ DOLANN, DTOT(5), DOL, FT2NET , BC(40), FSR
6 COMMON/CONC2/ NUMNEW, NUMADD, NUMREP, NDEMO
7 COMMON/CONC3/ SP1, SP2, SP3, SPD
10 COMMON/CONC4/ TCNEW, TCADD, TCREP
11 COMMON/CONC5/ FRDCLN, FRDOLA, FRDOLR
12 COMMON /CDEMO/ POP, STU(2), STFA(2), STFN(2), CSTF(2)
13 COMMON/CPDM/ CPS, PSTFA(2), WUCP(2)
14 DIMENSION NUMNEW(5,5), NUMADD(10,5), NUMREP(5,5), NDEMO(5,40), SP1(5),
1 SP2(10), SP3(5), SPD(5), TCNEW(5), TCADD(10), TCREP(5), FRDCLN(5,5),
2 FRDOLA(10,5), FRDOLR(5,5)
15 DIMENSION A1(3), B1(3), DNUC(5,3), DRUC(5,3), DAUC(10,3),
1 DN(3), DR(3), DA(3), DXXX(3), NX(3), CST(3)
16 DIMENSION PF(4), IYPF(4)
17 10 FORMAT(8F10.0)
20 11 FORMAT(F10.0)
21 IF(T .GT. 0) GO TO 300
24 DO 80 J = 1,4
25 IYPF(J) = IYF(J)
26 PF(J) = 0.0
27 DO 75 I = 1,2
30 75 PF(J) = PF(J) + STUF(J,I)
32 80 CONTINUE
34 DO 100 I=1,3
35 B1(I) = (PF(I+1)-PF(I))/FLOAT(IYPF(I+1)-IYPF(I))
36 A1(I) = PF(I) - B1(I)*FLOAT(IYPF(I))
37 100 CONTINUE
41 NPER = STOPTH - STARTM + 1
42 READ(5,10) (BC(I),I=1,40)
47 READ(5,11) FSR
50 GO TO 500
C T IS GREATER THAN ZERO
51 300 JJT = T + 2
52 LL1 = ((JJT - IYPF(1))/5) + 1
53 APF3 = A1(LL1) + B1(LL1)*FLOAT(JJT) + PSTFA(1)+PSTFA(2)
1+STFA(1)+STFA(2)
C CALCULATE FLOOR SPACE IN THREE YEARS
54 UCH = FLOAT(NUMNEW(1,3)+NUMNEW(1,4)+NUMNEW(1,5))*SP1(1)
55 UCI = FLOAT(NUMNEW(2,2)+NUMNEW(2,3)+NUMNEW(2,4))*SP1(2)
56 UCL = FLOAT(NUMNEW(3,1)+NUMNEW(3,2)+NUMNEW(3,3))*SP1(3)
57 UCA = 0.0
60 DO 310 I=1,5
61 DO 309 J=1,3
62 309 UCA = UCA + FLOAT(NUMADD(I,J))*SP2(I)
64 310 CONTINUE
66 LLT = T - STARTM + 1
67 UCHR = FLOAT(NUMREP(1,3) + NUMREP(1,4)+NUMREP(1,5))*SP3(1) -
1 FLOAT(NDEMO(1,LLT+2)+NDEMO(1,LLT+1)+NDEMO(1,LLT))*SPD(1)
70 UCIR = FLOAT(NUMREP(2,2) + NUMREP(2,3)+NUMREP(2,4))*SP3(2) -
1 FLOAT(NDEMO(2,LLT+2)+NDEMO(2,LLT+1)+NDEMO(2,LLT))*SPD(2)
71 UCLR = FLOAT(NUMREP(3,1) + NUMREP(3,2)+NUMREP(3,3))*SP3(3) -

```



015 SISSCN - SDONE -  
SN SOURCE STATEMENT

FORTRAN SOURCE LIST CONST2

1 FLOAT(NDEMO(3,LLT+2)+NDEMO(3,LLT+1)+NDEMO(3,LLT))\*SPD(3)

72 XXX = UCH + UCI + UCL + UCA + UCHR + UCIR + UCLR

73 YYY = FT2NET + XXX

74 RATIO1 = YYY/APF3

75 IF(RATIO1 .GT. FSR) GO TO 500

C CALCULATE TOTAL EXPENDITURES FOR THIS AND THE NEXT 2 YEARS

C NEW AND REPLACEMENTS

00 DO 330 I=1,3

01 LL5 = 7 - I

02 DO 325 K=1,3

03 DNUC(I,K) = 0.0

04 DRUC(I,K) = 0.0

05 JMAX1 = LL5 - K

06 LL4 = K - 1

07 DO 320 J=1,JMAX1

10 NZ = J + LL4

11 DNUC(I,K) = DNUC(I,K) + FLOAT(NUMNEW(I,J))\*TCNEW(I)\*FRDOLN(I,MZ)

112 DRUC(I,K) = DRUC(I,K) + FLOAT(NUMREP(I,J))\*TCREP(I)\*FRDOLR(I,MZ)

113 320 CONTINUE

115 325 CONTINUE

117 330 CONTINUE

C ADDITIONS

21 DO 345 I=1,5

22 DO 340 K=1,3

123 DAUC(I,K) = 0.0

24 JMAX1 = 4 - K

25 LL4 = K - 1

126 DO 335 J=1,JMAX1

127 NZ = J + LL4

30 DAUC(I,K) = DAUC(I,K) + FLOAT(NUMADD(I,J))\*TCADD(I)\*FRDOLA(I,MZ)

131 335 CONTINUE

133 340 CONTINUE

35 345 CONTINUE

C SUMMING ACROSS ALL SCHOOL TYPES

137 DO 360 K=1,3

40 DN(K) = 0.0

41 DR(K) = 0.0

142 DO 350 I=1,3

143 DN(K) = DN(K) + DNUC(I,K)

144 350 DR(K) = DR(K) + DRUC(I,K)

146 DA(K) = 0.0

147 DO 355 I=1,5

150 355 DA(K) = DA(K) + DAUC(I,K)

152 360 CONTINUE

C SUMMING ACROSS ALL CONST TYPES

154 DO 365 K=1,3

155 365 CXXX(K) = DN(K) + DR(K) + DA(K)

157 DO 370 K=1,3

160 IF(DXXX(K) .GT. BC(LLT)) GO TO 500

163 370 CONTINUE

C ADD SOME NEW SCHOOLS

165 FXXX = 0.0

166 DO 385 J=1,3

167 CST(J) = 0.0

170 385 NX(J) = 0

| 015 | SISSON - SCONE -                            | FORTRAN SOURCE LIST CONST2 |
|-----|---------------------------------------------|----------------------------|
| ISN | SOURCE STATEMENT                            |                            |
| 172 | 391 MXX1 = 0                                |                            |
| 173 | MXX2 = 0                                    |                            |
| 174 | 392 DO 395 K=1,3                            |                            |
| 175 | CST(K) = CST(K) + TCNEW(3)*FRDOLN(3,K)      |                            |
| 176 | IF((DXXX(K)+CST(K)) .GT. BC(LLT)) GO TO 430 |                            |
| 201 | 395 CONTINUE                                |                            |
| 203 | NX(3) = NX(3) + 1                           |                            |
| 204 | FXXX = FXXX + SP1(3)                        |                            |
| 205 | RATIO2 = (YYY + FXXX) / APF3                |                            |
| 206 | IF(RATIO2 .GT. FSR) GO TO 435               |                            |
| 211 | MXX1 = MXX1 + 1                             |                            |
| 212 | IF(MXX1 .LT. 4) GO TO 392                   |                            |
| 215 | 396 DO 400 K=1,3                            |                            |
| 216 | CST(K) = CST(K) + TCNEW(2)*FRDOLN(2,K)      |                            |
| 217 | IF((DXXX(K)+CST(K)) .GT. BC(LLT)) GO TO 430 |                            |
| 222 | 400 CONTINUE                                |                            |
| 224 | NX(2) = NX(2) + 1                           |                            |
| 225 | FXXX = FXXX + SP1(2)                        |                            |
| 226 | RATIO2 = (YYY + FXXX) / APF3                |                            |
| 227 | IF(RATIO2 .GT. FSR) GO TO 435               |                            |
| 232 | MXX2 = MXX2 + 1                             |                            |
| 233 | IF(MXX2 .LT. 2) GO TO 396                   |                            |
| 236 | DO 405 K=1,3                                |                            |
| 237 | CST(K) = CST(K) + TCNEW(1)*FRDOLN(1,K)      |                            |
| 240 | IF((DXXX(K)+CST(K)) .GT. BC(LLT)) GO TO 430 |                            |
| 243 | 405 CONTINUE                                |                            |
| 245 | NX(1) = NX(1) + 1                           |                            |
| 246 | FXXX = FXXX + SP1(1)                        |                            |
| 247 | RATIO2 = (YYY + FXXX) / APF3                |                            |
| 250 | IF(RATIO2 .GT. FSR) GO TO 435               |                            |
| 253 | GO TO 391                                   |                            |
| C   | BUDGET CONSTRAINT REACHED                   |                            |
| 254 | 430 GO TO 435                               |                            |
| C   | DESIRED SPACE REACHED                       |                            |
| 255 | 435 DO 440 I=1,3                            |                            |
| 256 | NUMNEW(I,1) = NUMNEW(I,1) + NX(I)           |                            |
| 257 | 440 CONTINUE                                |                            |
| 261 | 500 RETURN                                  |                            |
| 262 | END                                         |                            |

|             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <u>OPNS</u> | Computes overheads.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 1 - 10      | Set up core                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 11 - 34     | Read in overhead factors and initial rates.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 35 - 37     | I = factor index<br>FLATN(I) = inflation factor for this year, TBASE, years after start.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 41 - 51     | <p>THLTH = cost of health services</p> <p>RIHLTH, R2HLTH = average health service cost per student in each eara</p> <p>TTA = transportation cost</p> <p>RITTA, R2TTA = average transportation cost per student</p> <p>TCNSER = contract service cost</p> <p>RINSR = average contract service cost per student</p> <p>R2CNSR = average contract service cost per square foot of building space</p> <p>TBKSED = cost of books and educational materials</p> <p>R1BE, R2BE = average cost of books, etc., per student</p> <p>PERC = percent of students using CAI equipment</p> <p>TEQ = equipment related costs</p> <p>RIEQ = equipment related costs per student with CAI (assumed to be 1/10th as great without CAI).</p> <p>TRMEQ = equipment maintenance and repair costs</p> <p>RRMEQ = cost of maintenance per dollars worth of equipment</p> <p>TDS = debt service cost</p> <p>DOLANN = capital dollars spent this year</p> <p>DFACT = average debt service per capital dollar expended.</p> |
| 52          | Total overhead, TOH.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |



015 SISSCN - SDONE - FCRTAN SOURCE LIST  
 ISN SOURCE STATEMENT

```

0 $IBFTC CPNS
1 SUBROUTINE CPNS
2 INTEGER T, STARTM, STOPTH, RO
3 COMMON/COPNS/TPOM, TEQ, TBKSED, TTA, THLTH, TRMEQ, TDS, TCNSER, TOH
 1, R1EQ, R2EQ
4 COMMON/CDEMO/POP, STU(2), STFA(2), STFN(2), CSTF(2)
5 COMMON /CONC1/ DCLANN, DTOT(5), DCL, FT2NET , BC(40), FSR
6 COMMON/MASTER/T, STARTM, STOPTH, RO, DOLCEQ, EPS, EL, TDOLEQ
7 DIMENSION R(10), FLATN(10)
10 INTEGER TBASE
11 IF(T.GT.0)GO TO 8
14 READ (5,4) (R(I),I=1,7)
21 4 FORMAT (7F4.3)
22 6 FORMAT(2F6.3)
23 READ(5,6)R1HLTH,R2HLTH
24 READ(5,6)R1TTA,R2TTA
25 READ(5,6)R1BE,R2BE
26 READ(5,6)R1EQ,R2EQ
27 READ(5,6)R1CNSR,R2CNSR
30 7 FORMAT(F7.4)
31 READ(5,7)DFACT
32 READ(5,7)RPOM
33 READ(5,7)RRMEQ
34 TDS = 10.E6
35 TDOLEQ = 12.E6
36 RETURN
37 8 TBASE=T-STARTM
40 DO 5 I=1,10
41 5 FLATN(I)=(1.C+R(I))*TBASE
43 THLTH=(R1HLTH*STU(1) + R2HLTH*STU(2))*FLATN(1)
44 TTA=(R1TTA*STU(1) + R2TTA*STU(2))*FLATN(2)
45 TCNSER = (R1CNSR*POP+R2CNSR*FT2NET)*FLATN(3)
46 TBKSED=(R1BE*STU(1) + R2BE*STU(1))*FLATN(4)
47 TEQ=(R1EQ*STU(1) + R2EQ*STU(2))*FLATN(5)
50 TRMEQ = RRMEQ*TDOLEQ*FLATN(6)
51 TPOM = RPOM*FT2NET*FLATN(7)
52 TDS = DCLANN*DFACT+TDS
53 TOH=TPOM+TEQ+TBKSED+TTA+THLTH+TRMEQ+TDS+TCNSER
54 RETURN
55 END

```

EQPURC

- 1 - 7           Set up core
- 10 - 17       Reset parameters for each run (when T = STARTM)
- 20 - 60       Compute equipment expenditure DOLCEQ which must  
be less than the budget limit EL.  
EPS = Equipment (capital cost) required per student  
for CAI.  
POP = total enrollment.

Calculate share of budget for equipment for area 2  
(which is weighted by a factor FS to be proportionately  
greater than area 1).

- I           = area index
- E           = total capital needed in area
- DOL       = capital spent this year
- TDOL      = capital for CAI spent to date
- TODLEQ   = total capital spent to date
- XW2       = effective staff student ratio: varies between  
the basic ratio, X2, and the rate with CAI, XC2,  
in proportion to the fraction of students on CAI.
- PERC      = percent of students using CAI.

025 SISSON SDCAI  
ISN SOURCE STATEMENT

## FORTRAN SOURCE LIST

```

0 $IBFTC EQPURC
1 SUBROUTINE EQPURC
2 INTEGER T, STARTM
3 REAL M
4 COMMON/MASTER/T,STARTM,STOPTM,RO,DOLCEQ,EPS,EL,TDOLEQ
5 COMMON /CDEMO/ POP,STU(2),STFA(2),STFN(2),CSTF(2)
6 COMMON /CEQ/ FS,XE2(2),XC2(2),X2(2),PERC
7 DIMENSIONDOL(2),TDOL(2),E(2)
10 IF (T.NE.STARTM) GO TO 1
13 DO 2 I=1,2
14 2 XE2(I)=X2(I)
16 TDOL(1)=0.
17 TDOL(2)=0.
20 1 DOLCEQ = EPS*POP
21 IF (DOLCEQ .GT. EL) DOLCEQ = EL
24 DO 10 I=1,2
25 10 E(I)=EPS*STU(I)
27 3 DOL(2)=(1./FS)*DOLCEQ*(STU(2)/POP)
30 IF (DOL(2).GT.DOLCEQ) DOL(2)=DOLCEQ
33 TDOL(2)=TDOL(2)+DOL(2)
34 IF (TDOL(2).LT.E(2)) GO TO 11
37 TDOL(2)=E(2)
40 DOL(2)=E(2)-TDOL(2)+DOL(2)
41 11 DOL(1)=DOLCEQ-DOL(2)
42 TDOL(1)=TDOL(1)+DOL(1)
43 IF (TDOL(1).LT.E(1)) GO TO 4
46 TDOL(1)=E(1)
47 DOL(1)=E(1)-TDOL(1)+DOL(1)
50 DOLCEQ=DOL(1)+DOL(2)
51 4 DO 5 I=1,2
52 5 XE2(I)=(TDOL(I)/E(I))*XC2(I)+((E(I)-TDOL(I))/E(I))*X2(I)
54 PERC=((TDOL(1)+TDOL(2)) / (E(1)+E(2))) *100.
55 TDOLEQ=TDOLEQ+DOLCEQ
56 WRITE(6,100) DOL(1),DOL(2),TDOL(1),TDOL(2),E(1),E(2)
57 100 FORMAT (1H0/1H0,6(2X,F10.0)/)
60 RETURN
61 END

```